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WEEKLY January 5-11, 2019

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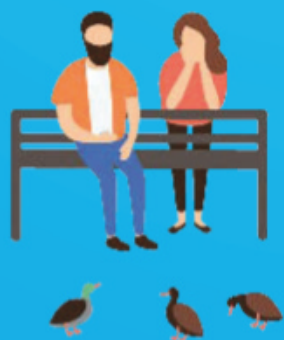
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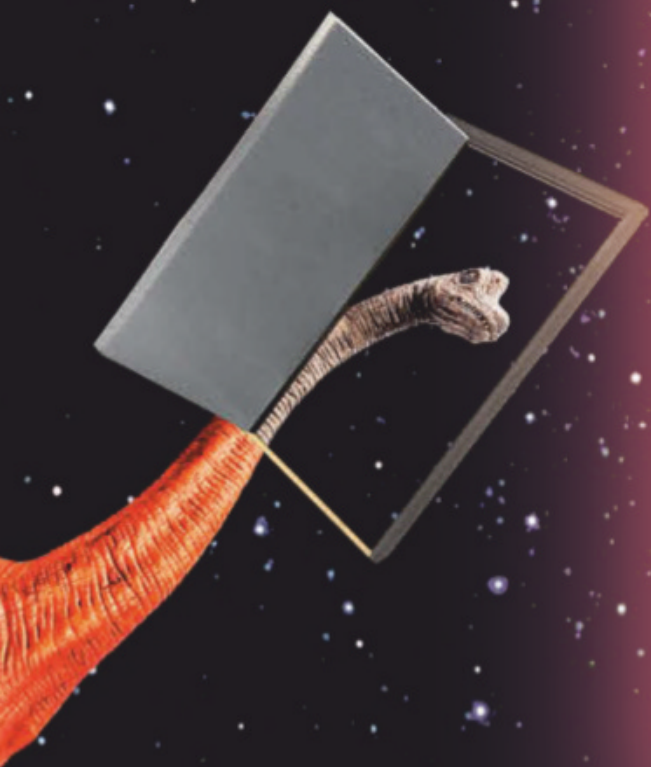
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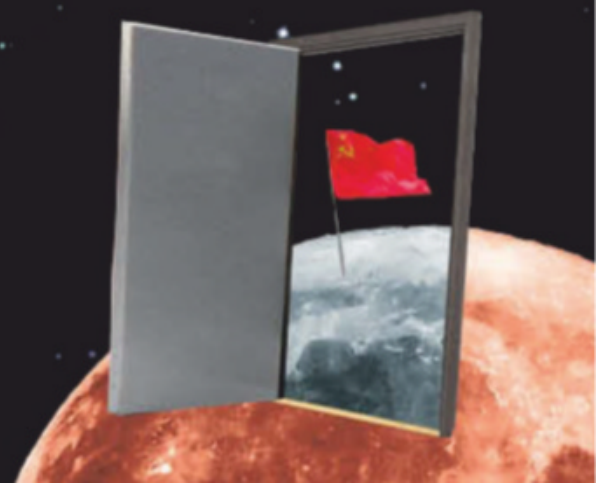
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PLAINPICTURE/AVIATION/MARK WAGNER

Here's to guilt-free flying

Our addiction to foreign travel means aviation must go green

MAJA ROSEN gave up flying a decade ago out of concern for its environmental impact. But when she became a mother and started hanging out with other parents, she didn't bring it up, even when the conversation turned to flying. It would have spoiled the mood.

Then in April 2018, her home country of Sweden introduced a tax on aviation. The climate impacts of flying were on the evening news and the mood changed. Rosen seized the moment. With her neighbour Lotta Hammar, she launched a campaign called "We stay on the ground", which has persuaded 10,000 people to

commit to avoid flights in 2019.

Kudos. But here's the hard truth: in the grand scheme of things, barely anyone will follow suit. The chattering classes tend to have a lot to say about the eco merits of avoiding meat, cycling and eating locally sourced food. But that morality generally evaporates when it comes to flying.

We can't rely on international agreements to curb aviation emissions either. Yes, the UN has brokered a deal to cap aviation emissions beyond 2020. But it lacks real bite, allowing airlines to continue emitting carbon provided they offset it.

All this means we could really do with green tech riding to the rescue. Here, at least, there is a little good news. Even rather simple measures like freeing planes to fly in straighter lines could feasibly cut carbon emissions (see page 32). Hybrid electric aircraft are also in the pipeline. And we already know that planes can mix up to 50 per cent biofuels into their tanks and fly safely.

It's time to redouble our efforts to make planes green. In the meantime, if you are still looking for a New Year's resolution, you might want to think about joining those 10,000 Swedes. ■

Best intentions

HAVE you already broken your New Year's resolution? If so, don't be too hard on yourself.

Studies show that it usually takes around two months to form a new habit, and sometimes up to a year. Even the inveterate self-improvers among us can struggle. So it helps to know that your goal is really worthwhile.

That is why we decided to apply

some science to identify five things you really should start doing in 2019 – and five you should stop (see page 26).

Reading our list, you might be surprised at how many good habits you already possess. You may also conclude that living better isn't always as onerous as you think. For a start, you can ditch your gym membership.

Also, instead of aiming for a dry January free of all alcohol, try cutting back and going damp instead – it could do you more good in the long run.

And what isn't to like about the idea of making more time for nature or getting more sunshine in your day?

The main message, though, is that 1 January is just an arbitrary date. Any time is a good time to improve your life. Here's to a very happy New Year. ■



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NEWS & TECHNOLOGY

Young blood tested on Parkinson's

Can an extract made from donated blood reverse cognitive decline?

Alice Klein

BLOOD from young adults is being trialled as a treatment for Parkinson's disease by a firm that wants to use the therapy to target neurodegenerative conditions.

Alkahest, a firm co-founded by Tony Wyss-Coray of Stanford University, California, has already tested blood-based treatments in people with Alzheimer's disease. In the latest trial, 90 people with Parkinson's – mostly in their 70s and 80s – will receive injections five days in a row, and then again three months later. Tests will determine whether the treatment improves their memory, attention, language skills or other cognitive abilities.

The trial is inspired by research by Wyss-Coray and others at Stanford University showing that cognitive declines in old mice can be reversed by giving them injections of blood from young mice. Since this discovery, Wyss-Coray has been trying to work out precisely what it is in young blood that drives this anti-ageing effect.

He and his team have spent the

"We don't know why young blood has rejuvenating properties, but it may be due to particular proteins"

past few years injecting different extracts from young human blood into old mice to see which have the most restorative effects. They haven't specifically sourced blood from young people, but are using blood from collection banks whose overall average donor age is 32.

Although we don't yet know why young blood may be rejuvenating, one idea is that younger bodies make restorative proteins that older bodies don't.



ZOOMAR GMBH/ALAMY STOCK PHOTO

Wyss-Coray's experiments have indicated that a certain "fraction" of young blood – a mixture of about 1000 different proteins – has particularly powerful effects. After old mice were injected with this fraction, they performed as well as young mice in cognitive tests, grew new brain cells and had less brain inflammation, says Alkahest CEO Karoly Nikolich. "We believe it contains the majority of beneficial proteins that are responsible for cognitive improvements," he says.

If the firm is right, this approach may prove more successful than earlier trials, which simply used blood plasma transfusions in an effort to relieve mild-to-moderate Alzheimer's disease. Results from a trial in 18 people last year hinted at small cognitive improvements, but the study was too short and

too small to know for sure if the treatment worked.

In April 2018, Alkahest began a larger trial in people with mild-to-moderate Alzheimer's, this time giving them just the fraction of blood it believes has the most rejuvenating effects. It is now beginning to give this fraction of blood to people with Parkinson's, and hopes to begin trialling the same blood extract in people with severe Alzheimer's disease soon.

Mystery molecules

The researchers still don't know which of the 1000 proteins in the fraction are responsible for the mental improvements seen in old mice, or how they work, but they are now testing them one by one to find out.

The blood fraction may

Blood from young people may have proteins with rejuvenating powers

contain proteins that indirectly rejuvenate the brain by boosting the immune system, says Michal Schwartz at the Weizmann Institute of Science in Israel. "We now know that communication between the brain and immune system is pivotal for brain function, and that this communication seems to dysfunction in ageing and Alzheimer's," she says.

Alkahest hopes to identify the protein or group of proteins responsible for the therapeutic effects so synthetic versions can be made in the lab, instead of having to be isolated from donor blood, says Nikolich.

This would be a major advantage as donor blood is in limited supply, says David Irving at the Australian Red Cross Blood Service. People receiving young blood for Alzheimer's or Parkinson's would need regular transfusions, since the beneficial proteins are likely to break down over time, he says. "There certainly wouldn't be enough to go around if it was used for all patients with these conditions."

However, it may be tough to make the therapeutic agent, says Lorna Harries at the University of Exeter in the UK. "It is probably a complicated mix of things that might be difficult to replicate synthetically," she says.

It is unusual for a treatment to progress to clinical trials before its mechanism of action is understood, says Irving. But the blood fraction is likely to be safe, since the safety of blood transfusions is well established, and there is an urgent need for Alzheimer's and Parkinson's treatments, he says. ■

Exoskeleton for skiers helps fight fatigue

SKIERS and snowboarders could get an extra boost with the help of an exoskeleton.

The device helps someone hurtling down a mountain by providing extra power to their legs during turns and by cushioning big impacts, allowing them to stay on the slopes for longer.

San Francisco-based Roam Robotics created the exoskeleton called Elevate. It has mechanical parts that strap to the knees, thighs and ski boots, and is powered by a battery backpack with enough power for a full day on the piste. Altogether, the device weighs 9 kilograms.

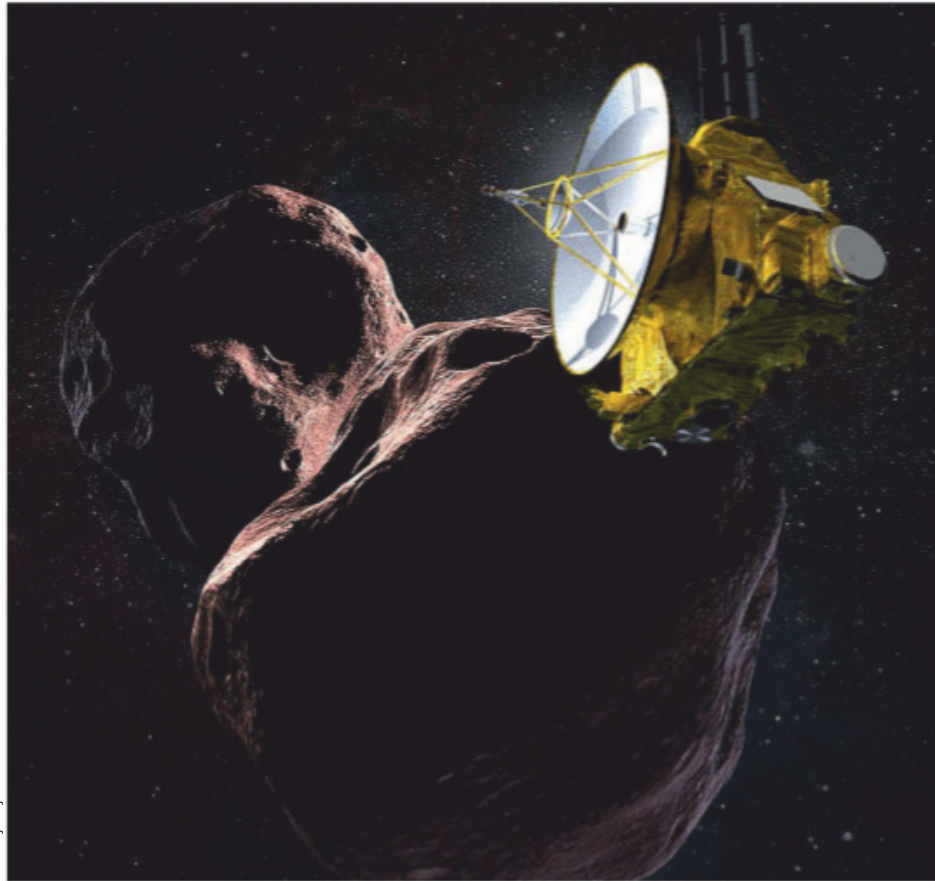
When someone is skiing or snowboarding with Elevate, it attempts to mimic their movements. The idea is that this gives the wearer greater control and more turning power with less effort.

The device has mechanical components called pneumatic actuators that can take up to 30 per cent of the wearer's weight. Roam Robotics says the actuators are lighter and more powerful than equivalent electric motors, which are often used in exoskeletons. It also says the device reduces the impact on the wearer's knees when moving downhill.

Skiers and snowboarders can rent the first units at the Lake Tahoe resort in California and, shortly, at Park City in Utah. They will eventually go on sale for around \$2500.

Lower-body exoskeletons are generally designed to enhance hikers' endurance or to help those with difficulty walking.

Conor Walsh, founder of the Harvard Biodesign Lab, has developed several exoskeletons for people with mobility problems. He says that using the devices for skiing is a logical extension of existing uses. "This seems like an excellent application for this type of technology," says Walsh. "The compliant nature of the system means it can provide assistance to a wearer but not feel restrictive." David Hambling ■



New Year's Day visit to a distant, tiny world

AS WE went to press, NASA's New Horizons spacecraft was set to fly past the most distant space rock we have ever visited. Since zooming by Pluto in 2015, the probe has been heading ever further from home, towards a tiny world called 2014 MU69. If all went to plan, it would have buzzed the space rock, nicknamed Ultima Thule, on New Year's Day.

The rock is about 6.6 billion kilometres from Earth. It was only discovered in 2014 during a search for potential targets for New Horizons, so we know very little about it.

We do know that it is a mere 30 kilometres or so across – less than 2 per cent of Pluto's diameter – which has made getting there incredibly difficult. "It's a lot harder than Pluto," says mission leader Alan Stern. "Instead of being the size of the continental US, it's the size of Boston. Being 100 times smaller means it's 10,000 times fainter."

That, combined with having had only four years to track the

rock's trajectory, makes it a much trickier target. If all goes well, New Horizons will hurtle by only 3500 kilometres from MU69's surface at more than 14 kilometres per second.

Photographing the rock will be like taking a picture from a moving car of a gnat hovering

"It will be like taking a picture from a moving car of a gnat that's hovering by the side of the road"

beside the road – and with so little sun that it is essentially dark.

The difficulty doesn't end there: the craft's plutonium-based batteries have been degrading since the launch 13 years ago, so the team will have to be careful about which instruments to use. The battery can now only power the equivalent of three standard light bulbs at any one time, says Stern.

The team is already on the lookout for any dust, rocks or rings that might be around Ultima

Thule. This is not just for the sake of scientific discovery, but also because they pose the greatest danger to the spacecraft. "If there is orbiting debris, even something literally the size of a rice pellet, at that speed it would shred New Horizons," says Stern. "If it doesn't signal on fly-by morning and say 'I'm here and everything's fine', that's probably what happened."

But if everything goes well, the probe will send back a wealth of data in the first few days of 2019. As well as images, there will be information on MU69's surface composition and its temperature. The best images will be the hardest to get. As New Horizons passes by, it will take a string of high-resolution photos along its trajectory. These should look even better than the ones taken at Pluto because the craft will be more than three times as close to its target.

But if our estimates of Ultima Thule's location are even a little off, it could end up out of the frame, leaving us with nothing but empty space. "If that Hail Mary pass works, it's going to be spectacular," says Stern.

One of the first things we will find out is whether Ultima Thule is one object with two lobes, shaped a bit like an unfinished snowman, or two rocks orbiting one another. It could even be several boulders trapped in a sort of floating rockslide.

Ultimately, the hope is that Ultima Thule will teach us about the beginnings of the solar system and its planets. Rocks like this were the precursors to Earth and the other planets. Because it is so far from the sun and too small to undergo geological activity, it will be the most pristine planetary building block we have ever visited.

"Never before have we seen something that's this wild and woolly," says Stern. Leah Crane ■

NEWS & TECHNOLOGY

Stork-bot makes airdrops a cinch

Sam Wong

AN AUTONOMOUS paraglider inspired by nature could help armies to resupply troops in dangerous places, or deliver humanitarian aid to disaster zones. The British Army trialled the unusual aerial vehicle during a recent month-long combat exercise.

Called Stork, the glider can take off and land in very tight spaces. It can fly itself to preprogrammed coordinates, using either GPS or a vision-based navigation system if GPS is not available.

Stork's small, three-wheeled chassis has a motor for propulsion. When airborne, both are suspended from a paraglider wing that fills with air as it moves forward. The aerofoil shape of the wing was inspired by the aerodynamics of eagles' wings.

Paragliders are a rare example from engineering of a hydrostatic skeleton, a structure supported by air or liquid. The idea is the basis for a wide variety of biological structures from the bodies of worms to human tongues, and it has benefits for industrial design, as well.

"It means you've got a wing you can pack into a tiny bag and it weighs almost nothing," says Adrian Thomas, a four-time UK paragliding champion and co-founder of Animal Dynamics, the company that created Stork.

Stork's navigation systems are also influenced by animal behaviour, such as the way pigeons use features on the ground to navigate. Like birds, the system avoids obstacles using the principle of optic flow: how quickly objects in the field of view get bigger as you travel tells you how far away they are.

The British Army put Stork through its paces by simulating delivery missions on Salisbury Plain in the UK. This involved parachuting packages on to the edge of a forest, or a house on the edge of a model town.

"They were out in the wind and rain, managing to do autonomous deliveries in scenarios representing military missions and humanitarian aid delivery missions for a variety of loads," says Peter Stockel from the UK's Defence Science and Technology Laboratory (DSTL).

The craft did well in challenging



ANIMAL DYNAMICS

A version of this animal-inspired glider could carry people or trucks

weather conditions, says Thomas. "It was more successful than I thought was remotely possible."

One version of the paraglider weighs around 50 kilograms and can carry up to 30 kilograms. A larger version weighs 150 kilograms and can lift up to 100 kilograms, so could be used to evacuate casualties. Animal Dynamics plans to make even bigger models, which could carry trucks to hard-to-reach areas. Thomas expects to have Stork on the market in 2020.

Stork is one of five systems

being evaluated in phase two of the Autonomous Last Mile Resupply competition, a DSTL-led project challenging commercial partners to develop technology to support military operations. The rivals include winged aircraft, quadcopters and ground vehicles.

Animal Dynamics also has DSTL funding to develop a tiny flapping drone based on a dragonfly, which could be used by soldiers for reconnaissance. It's not yet ready for military testing, but in theory a flapping bot should cope with wind gusts better than rotor-based flyers such as the Black Hornet, a small drone the UK army uses now. ■

Liquid can form square droplets at a stretch

DROPS of liquid are usually round, but they don't have to be. Researchers sandwiched drops of glycerol between stretched elastic films to see what shapes they could make - and were surprised to produce a square.

Rafael Schulman and Kari Dalnoki-Veress at McMaster University in Canada started with a thin film lying flat on a silicon surface, and deposited

a droplet around 100 nanometres in diameter on top. Then they placed a second film over the droplet. When the tension in the top film was equal in all directions, the droplet's outline was circular, viewed from above.

From the side, the droplet looked like a tiny dome sitting on a flat surface.

When they stretched the top film in one direction before placing it on the droplet, the liquid took on an oval shape, elongating in the same direction as the film.

Finally, they stretched the bottom film in one direction and the top film in another, at 90 degrees to the first.

Now the trapped droplet took on a square shape with slightly rounded corners (*Physical Review Letters*, doi.org/gfrfn8).

"We were surprised to see this," says Dalnoki-Veress. "The lowest energy state for a liquid droplet is a round spherical cap, typically. That's why a droplet on a spider web is round, that's why a droplet on a leaf is a little spherical cap. But here you

"Here you have an example of nature creating a completely counter-intuitive structure"

have an example of nature creating a structure which is completely counter-intuitive."

Now that we understand how to manipulate liquids into shapes between soft films, we can make nearly any shape, symmetrical or not, by playing with the tension of the films, says Dalnoki-Veress.

This method could be used to make arrays of small lenses that focus light in unusual ways. When the researchers shone a laser through the square droplet, for example, they found that it made a cross-shaped pattern. Chelsea Whyte ■

Cold atoms put on a quantum fireworks show

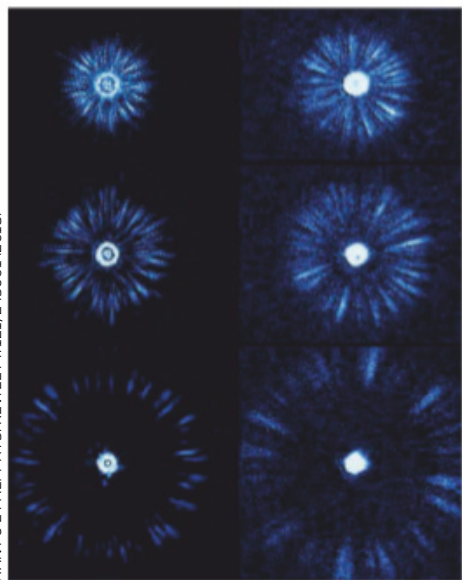
IT'S a big boom, only on a miniature scale. When waves build up in a quantum fluid of ultracold caesium atoms, they can cause the atoms to ripple outwards in a starburst shape, creating beautiful, tiny, fireworks.

The fireworks occur in a Bose-Einstein condensate (BEC), a quantum gas made of particles called bosons cooled to near absolute zero. Caesium atoms are bosons, so Han Fu at the University of Chicago and her colleagues placed a highly cooled gas of these atoms in a disc-shaped trap formed by lasers, which held the atoms in place. The whole thing was only 26 micrometres across, the size of some bacteria, because large BECs are hard to make.

The team suffused the trap with a magnetic field of changing strength. This pumps energy into the system, exciting the atoms to higher energy states. "Bosons are copycats: they like to be in the same state," says Fu. "Once a few caesium atoms are excited, more will want to join them."

Fu found that this follow-the-leader behaviour creates a self-amplifying effect, with ripples of atoms getting ever more energetic (*Physical Review Letters*, doi.org/gfphmb). Eventually, they can bust out of the trap like waves splashing over a levee. The result is a celebratory firework of frozen caesium (pictured below).

Leah Crane ■



HAN FU ET AL / PHYS. REV. LETT. 121, 243001 (2018)



BLICKWINKEL/ALAMY

Crayfish appear anxious after losing their armour

WHEN a crayfish sheds its protective exoskeleton, it becomes temporarily vulnerable to attack by predators. Now there is evidence that this leads to behaviour that resembles anxiety, and that this can be relieved using the same anti-anxiety drugs that humans take.

"They worry, they have an apprehension state that makes them avoid potentially dangerous areas. It's kind of like a primitive anxiety," says Pascal Fossat at the University of Bordeaux in France.

Fossat and his colleagues collected crayfish from swamps near Bordeaux and stored them in individual tanks that mimicked their natural habitat.

When the crayfish began to moult, the researchers placed them in a maze that had two dark sections and two lit sections, and recorded their behaviour.

Over the following two days, the crayfish showed a strong preference for hiding in the dark regions. If they did encounter the lit sections, they retreated into the dark in 80 per cent of cases.

For comparison, when the crayfish weren't moulting they typically spent about 30 per

cent of their time in the light.

"They're very weak when they remove the old exoskeleton, and the new one is totally soft until they eat the old one to get back the minerals that make the new exoskeleton stronger," says Fossat. "They're vulnerable, so they have to hide."

The team also took crayfish that weren't moulting and injected them with an ecdysteroid – a class of hormone that controls

"They worry and avoid potentially dangerous areas. It's kind of like a primitive anxiety"

moulting, produced by many animals with an exoskeleton. They found that the crayfish exhibited the same anxiety-like behaviour, avoiding light and retreating to the dark.

To explore whether it was possible to suppress this behaviour, Fossat and his colleagues took the animals they had treated with the ecdysteroid and injected them with anti-anxiety drugs developed for use in humans. The crayfish returned to spending about one-

Periodic moulting is needed for crayfish to be able to grow

third of their time in the light.

"They didn't have the apprehension from before," says Fossat (*Journal of Experimental Biology*, doi.org/cx38).

Robert Elwood at Queen's University Belfast in the UK says it is surprising that anti-anxiety drugs designed for human use also work on invertebrates, given that they last shared a common ancestor with us hundreds of millions of years ago. "I was taken aback [by] that," he says.

Fossat suspects crayfish may be capable of other primitive emotions – although it is a difficult subject to investigate because crayfish are biologically so different from humans.

Elwood says the animals may be acting on basic physiological mechanisms that humans have interpreted as feelings. But he says that new research is helping us understand the range of emotions invertebrates may experience.

"We've spent a lot of time worried about animal welfare, asking whether they are in stress or pain," he says. "Now we're beginning to turn that over and ask if we can say when an animal is happy or gleeful."

Chelsea Whyte ■

NEWS & TECHNOLOGY

Chewing gum tells of Stone Age life

Clare Wilson

SHE dined on duck, eels and hazelnuts, before settling down to a spot of tool-making, using pitch made from birch bark to stick stone blades to wooden handles. The dark-haired woman chewed the pitch for a while to make it more pliable, then, for some reason, spat out a wad without using it.

Six thousand years later, a team of archaeologists has extracted DNA from the discarded lump to shed light on the woman's diet, appearance and ancestry. They

"Once you see kids' teeth imprinted in the gum, you think it's no different to today"

have named her Lola as the pitch was found on the island of Lolland, part of modern-day Denmark.

"It's amazing – I know what she's been eating, what colour her eyes were, what colour her hair was," says Søren Sørensen at the Museum Lolland-Falster, which is running excavations on the island. "It's like standing face to

face with a Stone Age person."

Analysis of DNA from ancient human remains such as bones and teeth has increased in recent years, but this work is among the first to apply the technique to prehistoric "chewing gum".

The pitch is made by heating birch bark until it forms a black tar. It was used by many ancient people as a glue, for instance to stick arrowheads to shafts or knife blades to handles.

Small lumps of pitch have been recovered from several prehistoric sites across Europe, often with clear tooth marks. Chewing the goo would have made it more pliable. The stuff also has antiseptic properties, so people may have chewed it to help mouth wounds heal, or even for the same reasons we chew gum today: out of hunger or boredom.

There are also indentations made by children's teeth in some of the lumps. "Once you see kids' teeth imprints you think it's no different to today, when kids go around spitting out chewing gum," says Natalia Kashuba at the University of Oslo, Norway,



whose team published the first description of how DNA can be extracted from ancient gum towards the end of 2018. "I want to believe that it's also recreational, but there's no way to know."

Sørensen's team also managed to sequence DNA from bacteria in Lola's mouth. This suggested that she had a diet closer to that of hunter-gatherers than what we eat today (*bioRxiv*, doi.org/cx5g).

The team even recovered DNA from plants and animals that Lola had eaten not long before she chewed on the pitch. "You're not only getting inside their genetics, but also their lives," says team leader Hannes Schroeder at the University of Copenhagen.

Until recently, it wasn't clear how Stone Age people could have made the pitch. The substance is

When chewed, this birch goo could yield a handy glue for making tools

still used today as a home-made glue, but the bark has to be heated without oxygen, which is usually done by roasting it in a metal can. "We know that Neanderthals made pitch glue, so there had to be some method simpler than using a container," says Mikael Manninen at the University of Oslo.

Last year, we found one way they could have done it: by tightly rolling up sheets of birch bark, covering it with ash to keep air out, and then putting embers on top of it.

Manninen does not recommend chewing on the pitch, though – he has tried it himself. "It has this kind of bitter taste. I didn't chew it for long." ■

Frog has a taste for endangered tadpoles

AFRICAN clawed frogs are cannibals. They will willingly eat their own tadpoles – but they like eating those of an endangered South African frog even more.

Biologists are already familiar with the fact that African clawed frogs (pictured, right) will eat their own young. But John Measey at Stellenbosch University in South Africa and his colleagues wanted to



know whether other tadpoles were on the frog's menu. They were particularly concerned about the fate of tadpoles belonging to the Cape platanna, an endangered species that lives in ponds around Cape Town.

By placing African clawed frogs in tanks with tadpoles of their own species and those of the Cape platanna, the team found that the frogs prefer eating their endangered cousin's tadpoles (*African Journal of Ecology*, doi.org/cx3t).

Measey says the evidence suggests the African clawed frog can tell the difference between the two types of tadpole. "That is very bad news for

the Cape [platanna]," he says.

Partly due to their popularity as pets, African clawed frogs are now an invasive species on four continents. They don't occur naturally around Cape Town either, having exploited urbanisation to colonise the area.

"It's another interesting example where human alteration of the landscape has changed the playing field," says James Vonesh at Virginia Commonwealth University, a co-author of the study.

Measey thinks it may be necessary to physically remove clawed frogs from the environment to help the Cape platanna. Joshua Rapp Learn ■

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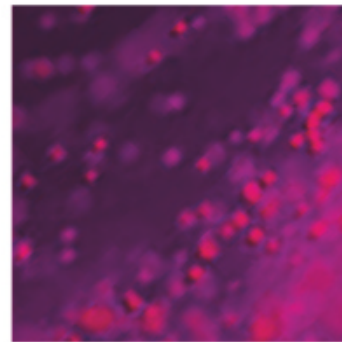
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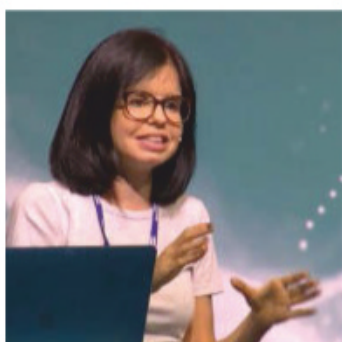
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Tara Shears
Why hasn't the LHC found anything new? (...or has it?)



NEWS & TECHNOLOGY

Sweat test could help spot PTSD early

ONLY some people who go through a traumatic event get post-traumatic stress disorder (PTSD), but for those who do, the condition can be devastating. A quick skin test could help spot those most at risk so they can be given support earlier.

People with PTSD can get nightmares and flashbacks after a traumatic event. Rebecca Hinrichs at Emory University in Georgia and her colleagues suspected that people's reactions soon after the event might shed light on their risk of developing the condition.

To find out, the researchers interviewed 144 people who attended a hospital emergency department after a traumatic experience like being in a car crash. While questioning each person for 5 minutes about their experience, the team placed electrodes on the palm of their hand to monitor their sweat level, which is commonly used to measure how alert someone is to a threat.

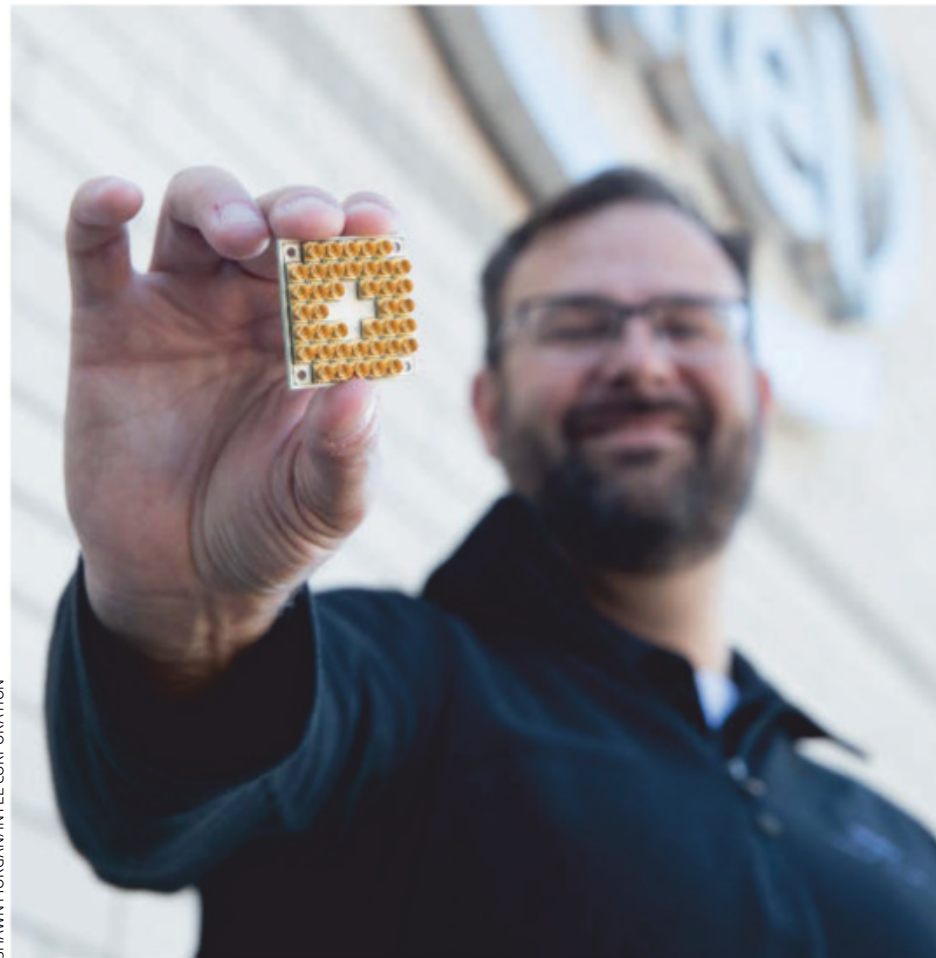
People who sweated the most during the interview were more likely to be diagnosed with PTSD six months later. However, the test wasn't perfect: it was good for ruling out people who wouldn't develop the condition, but it wrongly classed some people as being likely to develop PTSD who didn't, says Hinrichs.

She says that isn't too much of a problem because the kinds of talking therapy that would be recommended would help people deal with their experience regardless.

But Roger Pitman at Harvard Medical School says wrongly telling people they are at risk of PTSD could have downsides. "We don't know if the harm that would be done by alarming these people is equal to the benefit from treatment." This test is a useful first step, but we need more accurate measures, says Pitman.

The work was presented at a meeting of the American College of Neuropsychopharmacology.

Clare Wilson ■



SHAWN MORGAN/INTEL CORPORATION

Inside Intel's quantum quest

Chelsea Whyte

INTEL is taking a slow and steady approach to quantum computing. Competitors like Google may be racing to achieve so-called quantum supremacy, in which a quantum computer outperforms an ordinary one. But Intel's James Clarke has bigger ideas. He leads the firm's quantum computing research team, and says it is looking past near-term goals in order to be the first to make a device with a million qubits, or quantum bits – enough to have a real impact on the world.

How are you making a quantum computer?

We have spin qubits in silicon, which are like single electron transistors. We make billions of transistors today, so the thought is, if we can turn these into qubits – which is non-trivial –

they would have some key [scaling] advantages over the superconducting qubit [Google's preferred approach]. We aren't putting all our eggs in one basket, and the superconducting qubits are a little further along. We have a 49-qubit chip of those.

Why go for the long term?

What do I define as long-term success? Something that would change your life or mine – maybe a new drug. For that, you need very good qubits and you need a lot of them.

What is Intel's big goal?

Right now, the whole community is at, let's say, tens of qubits, maybe 50. And maybe with brute force you could make a chip bigger and bigger and get to about 1000. With 1000, you can probably do some interesting things. You can probably even find

Intel's James Clarke with a 17-qubit superconducting quantum chip

a couple of applications where you are doing a little bit better than a supercomputer.

My goal would be to find a way to get a million or a billion qubits together on a chip. That keeps me up at night. At Intel, we are less

"What do I define as long-term success? Something that would change your life or mine"

worried about the answers we will get from 50 qubits and more about how we will get to a million. We want to be the first to do that.

When will that be possible?

We are saying roughly 10 years. Some of the other companies in this field are saying something much nearer term. But if you look at the history of the evolution in microelectronics, it actually happened on a little bit longer scale than that. The first silicon transistor was in 1954, the first integrated circuit was in 1958 and the first microprocessor was in 1970.

Will I use a quantum computer in my lifetime?

The Cray-1 supercomputer came out in the mid-70s. I doubt anybody then would have said, "Hey, I bet 40 years from now, we are going to have these in our back pockets for listening to music and watching television." It is hard to know where we will be in 30 to 40 years, so I wouldn't rule it out.

On a more practical level, the first quantum computers will be hooked up to a supercomputer. Chances are, it will take a team of experts who are familiar with programming the supercomputer and programming a quantum computer to get the information in or out. We need to develop the workforce to be able to do that. It doesn't really exist yet. Quantum computer programmers are few and far between. ■

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NEWS & TECHNOLOGY

The lost islands of the Galapagos

Colin Barras

MILLIONS of years before the Galapagos Islands existed, there was another archipelago in the same stretch of water off the west coast of South America. And it seems those long-vanished lands probably shaped the evolution of some of the unusual Galapagos wildlife that later inspired Charles Darwin's theory of evolution.

Today's archipelago probably owes its existence to a nearby geological phenomenon, a plume of unusually hot rock rising from deep in Earth's interior. When the plume meets the crust beneath the Pacific Ocean, it triggers intense volcanic activity, which forms underwater mountains that can grow tall enough to rise above sea level and become islands.

The parts of the Galapagos that lie near the plume today are about 3 million years old. But geologists think the plume is much older, and has been forming volcanic islands for much of the past 20 million years. These have since been dragged to the east and northeast of the Galapagos by drifting tectonic plates. During

this process, almost all of the island-volcanoes became inactive and sank below the water, where their remains can be found.

For the first time, researchers have worked out how big these lost lands were. Felipe Orellana-Roviroso and Mark Richards at the University of California, Berkeley, used data on the rate at which they sink to work

out how much land was above the waves at various points over the past 20 million years. They say that there is likely to have been a Galapagos-like archipelago off the west coast of South America for most of this time.

Their work suggests that 16.5 million years ago, the land area of the archipelago was 22,500 square kilometres, more than twice that of the current chain. Some of the lost islands had peaks that may have risen as much as 500 metres above sea level. The findings were

Galapagos species like the marine iguana seem to predate the islands

presented at a conference of the American Geophysical Union in Washington DC.

This tallies with earlier work. Kenneth Petren at the University of Cincinnati in Ohio and his colleagues previously highlighted that some Galapagos species, including beetles and marine iguanas, seem to have evolved in isolation for millions of years before the formation of the current islands. Orellana-Roviroso and Richards say these species must have lived on the earlier islands, migrating to the modern archipelago when it formed.

Given that the earlier archipelago was substantial, and its potential role as an ancestral home for some of the wildlife now living in the Galapagos, Richards and Orellana-Roviroso suggest naming it Darwinia, to honour Darwin, whose time in the current islands informed his theory of evolution by natural selection.

But Peter Grant of Princeton University, who studies the unique Galapagos finches, suggests a different approach to naming the lost lands. "Darwin never set foot on them, so [Darwinia] wouldn't be my choice," he says.

Instead, he suggests taking inspiration from the animal that is most likely to have occupied the ancient chain – the marine iguana. "By this logic, I would suggest Iguania is more apt." ■



TUI DE ROY/NATUREPL.COM

How to get rich people to donate more

APPEALING to wealthy people's sense of personal power rather than their community spirit seems to encourage them to give more money to charity.

Psychologists already knew that rich people value their individual ability to control events more than lower-income earners do, says Ashley Whillans at Harvard University.

Appealing to this independent

mindset encouraged wealthy people to donate more money to a charity aimed at ending poverty, found Whillans and her colleagues. That work was published in 2017.

The team has now tested whether fundraising appeals framed in this way increased the generosity of wealthy graduates of an Ivy League business school in the US, whose average starting salaries were in excess of \$100,000 per year.

The researchers sent letters to more than 12,000 alumni asking them to donate to the school.

The letters started with one of

two sets of words to appeal for their support: "Sometimes, one person needs to come forward and take individual action" or "Sometimes, one community needs to come forward and support a common goal".

Among the 4 per cent who donated, those who received the message that focused on individual action gave an average of \$432. In contrast, those who got the more community-minded

"We think that giving high-income earners a sense of control makes them want to give more"

appeal contributed \$270 on average (*PLoS One*, doi.org/cx4m).

"We think that giving high-income earners a sense of control makes them want to give more," says Whillans.

She believes that fundraising organisations could use these findings to boost their revenue. "Charities often use messages that highlight how positive the action is, like, 'it's so important to help the environment', but they may benefit from tailoring their messages to people's self-interested motivations instead," she says. Alice Klein ■

NEWS & TECHNOLOGY

Europe's biggest archaeological dig

Alison George

THE most extensive archaeological dig in Europe is under way in the UK, thanks to the high-speed train line being built between Birmingham and London (see map). Major construction projects like the new line, known as HS2, are an ideal opportunity to investigate the buried past. Before building work begins this year, archaeologists will investigate

60 different sites along the 240-kilometre route.

The digs will uncover 10,000 years of history, from the time of hunter-gatherers through to the Roman, Saxon, medieval and modern eras. "We expect to find archaeology from every period in our history," says Mike Court, the lead archaeologist on the project. Here are some of the highlights.

1 18TH-CENTURY BURIAL GROUND Birmingham

This Industrial Revolution-era graveyard is thought to hold more than 10,000 bodies, and 1500 have been recovered so far. The skeletal remains will tell us about the effects of 18th and 19th-century life on those living in Birmingham.

One intriguing finding is that some of the skeletons show evidence of dissection – probably by students at a nearby medical school in operation at the same time as the burial ground.

2 IRON AGE TO SAXON ERA SITE Boddington

Before any digs began, the route of HS2 was surveyed using laser scanners and magnetic detectors. "These techniques give a map of what's going on underground," says Court. They have thrown up surprises, including in what

"Major construction projects like the UK's HS2 train line are an ideal opportunity to study the buried past"

looked like an uninteresting field near the village of Boddington in Warwickshire.

The field wasn't thought to have been occupied in the past, but the surveys revealed a large Bronze Age or Iron Age structure, and others that appear to be Roman and Saxon, suggesting it may have been used for over 1000 years.

"If we find towns and settlements where we thought there weren't any, that's what this project is about," says Court.

3 WAR OF THE ROSES BATTLEFIELD Edgecote

The HS2 route runs close to the site of a key battle in the English civil war known as the War of the Roses. The battle took place on 26 July 1469.

Aside from accounts by Welsh poets, not much is known about this battle, so archaeologists are hoping to uncover arrowheads, weapons and possibly mass burial pits to figure out how it unfolded.

4 MEDIEVAL BURIAL GROUND St Mary's Church, Stoke Mandeville

Possibly the most interesting medieval site along the HS2 route is the graveyard of the demolished church of St Mary's in the village of Stoke Mandeville. Between 3000 and 5000 bodies were interred here, starting around the 12th century.

It is an unprecedented opportunity to investigate the population of a village over a long time period, says Court. "There's a good chance that we'll find burials due to the Black Death and subsequent bouts of plague."

5 BRONZE AGE DYKE Grim's Ditch

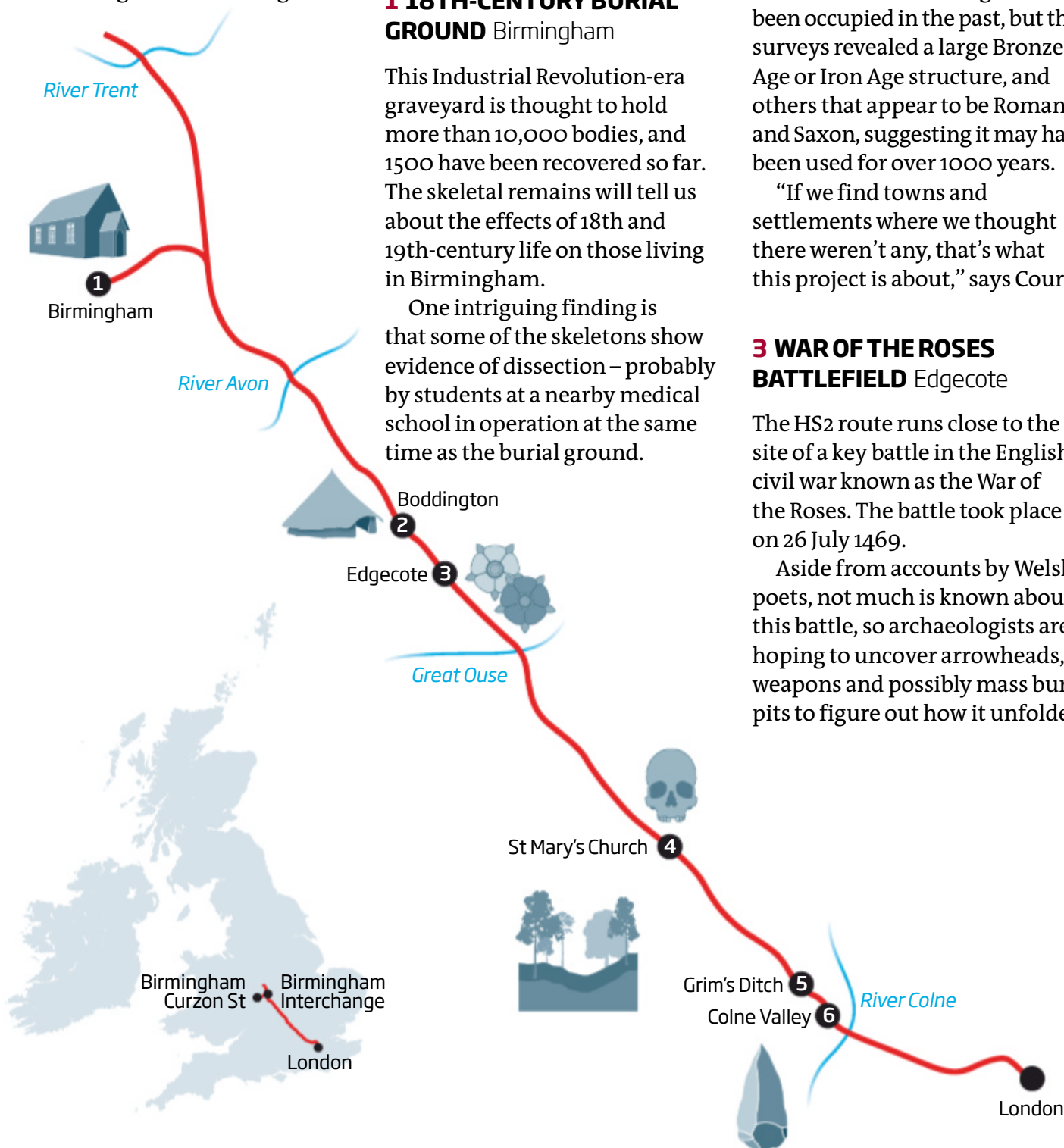
This long, deep ditch on the outskirts of London is thought to have been constructed in the Bronze Age or Iron Age, but we don't know why it was built. "We're hoping to solve the mystery of Grim's Ditch," says Court. It could mark the boundary of an ancient territory, or perhaps the route of migratory animals.

6 STONE AGE HUNTER-GATHERER SITE Colne Valley

The Colne Valley on the outskirts of London may have been an important place for the nomadic hunter-gatherer people living in Britain 10,000 years ago. At that time, low sea levels meant Britain was connected to mainland Europe, and archaeologists think that the Colne Valley may have been a migration route from Europe via river systems.

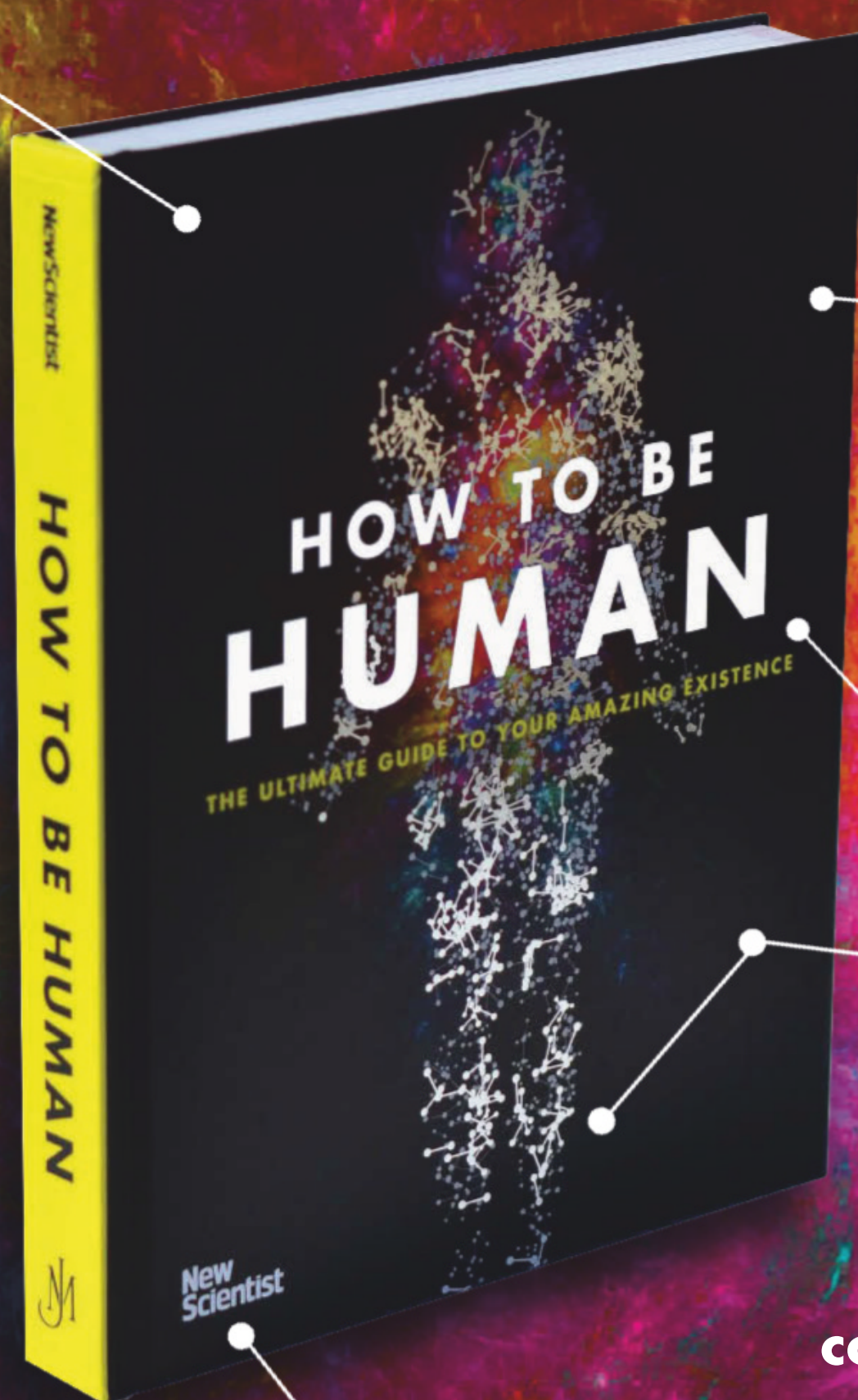
They will be looking for raised gravel areas in the river which might have been used by these ancient people as they followed animal herds.

"If we're really lucky we might find a butchery site, where they took down an animal like a mammoth," says Court, though that is probably unlikely. "I'd be happy if we find any evidence of human activity." ■



Humanity will need the equivalent of 2 Earths to support itself by 2030.

People lying down solve anagrams in 10% less time than people standing up.



About 6 in 100 babies (mostly boys) are born with an extra nipple.

60% of us experience 'inner speech' where everyday thoughts take a back-and-forth conversational style.

We spend 50% of our lives daydreaming.

Creative differences

As artificial intelligence algorithms play an increasing role in producing media, what will happen to the idea of copyright, asks **Leah Crane**

THIS week saw something that hasn't happened in decades. On 1 January, the US copyright protection on a host of books, films, sheet music and artwork expired. Works from 1923, including silent movie *The Ten Commandments* and Charlie Chaplin's film *The Pilgrim*, have now entered the public domain.

These works were granted a copyright extension by a 1998 law signed by US president Bill Clinton that retroactively added 20 years' protection to works created in 1923 and later. That time is now up. If no new laws are passed, even more work will lose its copyright, including the original Mickey Mouse film, *Steamboat Willie*, in 2024.

At the same time, advances in technology are leading some to wonder about the future of copyright altogether. As artificial intelligence algorithms play an increasing role in media production, questions of ownership are becoming fuzzy.

Creating something with an AI takes three steps. First, someone codes the algorithm itself, then it must be fed masses of data to teach it to recognise and mimic patterns, and finally the AI produces some sort of output.

When it comes to copyright, the big question is who owns that output: the person who built the algorithm, the person who picked the training data or the person who selected the specific output?

In some ways, this isn't a new conundrum: think of bands arguing over who should own the rights to a particular song when one member wrote the chord

sequence and another the solo, says Tom Lingard, an intellectual property and technology lawyer.

Elevating current AI systems to the status of bandmate is probably going too far. Both artists and lawyers say they are more like word-processing programs: if nobody types into one, there can be no essay. The software might check your spelling, but the thing that makes

"Without an artist to actually collect the data, the algorithm has no agency"

an essay unique is the writer.

By extension, we could say that anyone who feeds data into an AI owns the resulting work, and the AI's creators have no claim to the outputs, says Andres Guadamuz, a lecturer in intellectual property law at the University of Sussex, UK.

AI artist Janelle Shane agrees with this view of algorithms as sophisticated tools for realising an artist's vision. "It can seem like the machine is doing everything, but without an artist to actually collect the data, the algorithm has no agency," she says.

That's not the end of the issue. The data sets used to train AI generally consist of hundreds or thousands of images, songs or pieces of writing, some of which may be copyrighted themselves. Should the owners of these works have a claim on the output?

One argument is that this training process is equivalent to inspiration. "When musicians create music, they listen to music," says Guadamuz. "In some ways, feeding a machine-learning algorithm music or images is almost the same."

However, the act of a human



Human artwork may be pushed into a corner as AIs get creative

listening doesn't create an exact digital copy. By contrast, gathering a data set and feeding it into an algorithm requires the original work to be copied. Without the appropriate permissions, that is copyright infringement, says Lingard.

That doesn't mean that people who use AI to create things are likely to be sued. "It's really hard to prove anything in terms of the training data," says artist Mario Klingemann. "[The AI] doesn't cut out an eye and a mouth and make a collage of the new face. It learns to manipulate pixels so that a certain area looks like an eye." That means it can be impossible to retrieve the original images once the AI is trained.

Of course, if your AI is solely trained on extremely identifiable works, you are probably asking for trouble. For example, an AI fed all of Dr Seuss's children's

books will produce outputs that are very similar to the originals, perhaps even including Seuss's made-up words. For AI, it is a thin line between inspiration and plagiarism.

Ideas machine

More advanced AIs could raise a thornier question: can an algorithm claim copyright on its own creations? Current laws suggest not. For example, the US Copyright Office only recognises "the fruits of intellectual labor" that "are founded in the creative powers of the mind".

Because previous US case law has established that copyright can only be extended to "original intellectual conceptions of the author", it will only be granted to works with a human creator, meaning that AI-produced work can't be copyrighted. "It's sort of human fundamentalism, the idea that machines cannot do anything that we consider creativity," says Guadamuz.

Things are different in the UK, where the 1988 Copyright, Designs and Patents Act states that in the case of computer-generated work, "the author shall be taken to be the person by whom the arrangements necessary for the creation of the work are undertaken". A few other countries, including India, New Zealand and South Africa, have similar laws, allowing a human to claim computer-generated artwork as their own intellectual property.

Giving an AI ownership of its work wouldn't even make sense, says economist Marc Scheufen at the German Economic Institute. Copyright law is designed to encourage the production of new works by allowing their creators to profit exclusively from them and recoup their costs.

"As soon as you have an AI system that is able to create new art, the costs of producing art will be zero," says Scheufen. "There's no cost, so no incentive

is needed." In a world where everything is made by algorithm, there will be no need to compensate AIs for their work and thus no need for copyright.

This ease of creation could even end up being a serious threat to human artists. "You could get an AI to produce 20 million different songs and copyright them all and put them on some shelf and just wait until somebody else writes the song and sue them," says Klingemann. "I don't know if that's the future that we want to have."

The bottom line, then, is that copyright law is not yet equipped to handle the enormous amounts of data these sorts of AIs require and generate. "Right now, AI is not so sophisticated, so it doesn't have much commercial value," says Guadamuz. "When it crosses a certain threshold where we're going to have more sophisticated art or music or poetry, we're going to have to make a decision."

Yet serious money has already been paid for AI-created works, as demonstrated by the sale of an AI-generated portrait last year (see "AI creations for you to enjoy", right).

It is likely that the question of AI copyright will be answered by some future lawsuit that sets a precedent and trickles through the courts. If the ruling is that AI art cannot be copyrighted, it could kill the genre entirely as artists refocus on work that can pay their rent. Yet if the law decides that such art can be protected, it could damage other methods and industries as AIs flood copyright offices with millions of applications and simply wait for someone else to infringe them.

Regardless, this difficult decision is coming up fast. The key issue is whether a machine can truly create art on its own. If we decide it can, that opens the door to even larger consequences: if an algorithm can own copyright, what other rights should it have? It is a question that could barely be imagined in 1923. ■

AI CREATIONS FOR YOU TO ENJOY

PORTRAIT OF EDMOND DE BELAMY

This blurred and unfinished portrait bears a mathematical equation in place of the artist's signature - a hint that it was created using an algorithm. The trio of students behind the work trained borrowed code on 15,000 existing portraits, sparking questions over who really produced the work. It was sold by Christie's auction house in New York last year for \$432,500.



OBVIOUS AI/CHRISTIE'S

ZONE OUT

Director Oscar Sharp and AI researcher Ross Goodwin tasked their AI, Benjamin, with producing an entire short film in 48 hours. They fed it footage from public domain films, screenplays and footage of human actors. The AI generated a script, pasted the actors on to existing clips, and produced its own voiced dialogue and musical score. The result (below) is incredibly bizarre.



THEREFORE FILMS

HARRY POTTER AND THE PORTRAIT OF WHAT LOOKED LIKE A LARGE PILE OF ASH

Botnik Studios uses a customised, predictive text keyboard to produce parodies of books, TV shows and other media. By feeding its software with the *Harry Potter* novels, Botnik created a new one, which includes Ron eating Hermione's family.



JOHN PHILLIPS/GETTY

COMMENT

Quit carbon, and quick

January is a time to pledge to improve ourselves. World leaders should follow suit, says **Owen Gaffney**

STOP smoking? Lose weight? Play less *Fortnite*? It is the time of year to forgo instant gratification for long-term gain. For world leaders, getting serious about climate change offers the ultimate New Year's resolution.

Last year was the fourth hottest on record. An unprecedented heatwave in the northern hemisphere brought devastating wildfires and floods. And with an El Niño – the ocean phenomenon that raises global temperatures – spinning up in the Pacific, 2019 could be even hotter.

Despite the hype, the Paris Agreement on climate change has barely more legal status than your personal pledges for 2019, and lacklustre national commitments to the agreement risk committing the world to catastrophe.

It is now increasingly clear that, to curb the risk of disastrous climate change, certain things



must happen at set times: fossil fuel emissions must peak in 2020 and halve by 2030, then halve again by 2040 and so on each decade. My colleagues and I at the Stockholm Resilience Centre call this exponential decline the Carbon Law. Framing the problem this way can provide short-term focus to a long-term goal, something the Intergovernmental Panel on Climate Change backs.

The next two years setting us on the is path are critical for the planet. Every decision made now on energy, transport, buildings and industry will affect whether we can stick to the Carbon Law.

Can emissions peak by 2020? Yes. Between 2014 and 2016 there was almost no emissions growth, while economies still grew. In around 50 countries emissions have already peaked. Is it realistic to halve emissions by 2030? Yes. In fact, many firms and cities can

JOSIE FORD

Bearing the cost

Surrogacy should be a relationship, not a transaction, says **Natalie Smith**

SURROGACY law in the UK is in dire need of an overhaul. So it was no surprise when, last year, the body that oversees legal reform, the Law Commission, announced a project to make surrogacy rules “fit for the modern world”. A consultation paper is due in May.

I am a mother to two wonderful daughters born by surrogacy, who

are now nearly 8 years old. For the past four years, I have been pushing for new legislation.

The most hotly debated issue is whether surrogates in the UK should be paid. Former president of the Family Division of the High Court, James Munby, has said that serious consideration should be given to abolishing the UK's ban

on commercial surrogacy. Yet the largest UK survey on attitudes to this, published last month, shows that surrogates don't support a move towards commercialisation.

Over 70 per cent of surrogates agreed that they should only receive “reasonable expenses”. They are motivated by making families, not money. The existing surrogacy culture in the UK, based on trust, mutual respect and partnership, has grown because the law as it is puts altruism at the

“Surrogates are motivated by making families, not money. Altruism should be at the heart of surrogacy”

heart of surrogacy. That must stay.

Making it commercial would create problems. For example, in California payments to surrogates are typically equivalent to around £35,000. In total, surrogacy there can cost parents upwards of £100,000. We cannot be flippant about such sums. They are beyond most people. The real winners of a commercial model are surrogacy agencies and lawyers.

It is from these quarters that the call for commercial surrogacy comes loudest. Lawyers argue that payments are routine in the UK. In fact, there is no evidence that payments beyond reasonable expenses are routinely made.

For more opinion articles, visit newscientist.com/opinion

go far faster. Renewable energy is now 12 per cent of electricity production and wind and solar are doubling every three years. In 2018, the cost of green energy reached parity with fossil fuels in many regions, and is still falling. Over 50 per cent of the world's electricity will come from renewables by 2030, if we can stay the course. But only if the world halts investment in fossil fuels.

Momentum is there. Shipping giant Maersk has committed to being carbon neutral by 2050. In Norway, electric and hybrid cars went from 5 per cent of new sales to 50 per cent in five years. Volkswagen has resolved to go all-electric by 2040.

To lock in a clean-energy revolution in 2019, governments must create the right economic playing field by ending fossil fuel subsidies, pricing carbon fairly, setting adequate emissions standards and encouraging investment in renewables. Our *Exponential Climate Action Roadmap* shows how. António Guterres, secretary-general of the UN, will host a climate summit in September. Let us hope world leaders can tell him their climate resolutions have been kept. ■

Owen Gaffney is director of media at the Stockholm Resilience Centre

More clarity over what constitutes reasonable expenses, and better guidance, would go a long way to resolving key issues.

The focus of legal reform has to be where there is consensus: that parents should be recognised as such in law at or pre-birth. Currently, a surrogate is the legal mother of a child born this way, even if they are unrelated.

We need new surrogacy laws. Those laws must put the voices of surrogates, intended parents and their children front and centre. ■

Natalie Smith is a member of Surrogacy UK and chairs the Surrogacy UK Working Group on Legal Reform

ANALYSIS Women in science



NASA/ALAMY

Women finally get equal access to Hubble

Leah Crane

THE Hubble Space Telescope has a gender problem. For at least the past 16 years, female researchers have had their requests to use the world's most important telescope accepted at significantly lower rates than their male colleagues. But a switch to reviewing anonymised proposals is changing that, showing that selection processes can be biased against women.

Every year, astronomers around the world respond to an open call for proposals for time using Hubble. There can be up to 1000 proposals, with only 10 to 20 per cent given the green light to make observations.

In 2017, 27.5 per cent of the major proposals put forward were led by women. Of these, 13 per cent were approved, whereas proposals led by men had a 24 per cent approval rate. Previous years saw a similar disparity.

Time on the telescope is a coveted resource. "There's a real premium on getting Hubble time, and a lot of observational astronomers have built their careers with it," says Priyamvada Natarajan at Yale University, who led

Hubble's 2018 Telescope Allocation Committee (TAC).

It is particularly important for astronomers that don't have the funding or institutional backing to use other major telescopes, which have more restricted access. The gender disparity meant that under-represented researchers faced an additional disadvantage.

So the Space Telescope Science Institute, which oversees the selection proceedings for Hubble, decided it was time for a change. In 2017, it brought in Stefanie Johnson, a leadership and diversity expert from the University of

"Female researchers had their requests to use the Hubble telescope accepted at lower rates than men"

Colorado, to observe TAC meetings and advise on ways to mitigate the apparent bias.

Johnson says she was surprised at how little the discussions focused on the science at hand. Instead, she says, the committee often talked about the researchers themselves, their teams and their past work. "When they're

talking about the scientist then I think they can be a little more influenced by not just their gender but their age or their race or their school," says Johnson. "The differences may be small, but over time those little things add up."

She suggested that they review anonymised proposals instead, with all identifying information removed from applications. The first such review has just finished and proposals led by women had an 8.7 per cent success rate and those led by men had an 8 per cent success rate (the lower success rates were due to a rise in submissions).

"It was immediately apparent in the tone of the discussion that this was a fundamentally different kind of evaluation," says Natarajan. "It was much more fair, much deeper and more focused on scientific considerations." It may not seem huge, but it was a big shift towards equity and fairness, and Natarajan says that the process will continue in future.

Hubble is the first major instrument in physics or astronomy to switch to reviewing anonymised proposals. It might be the start of a reckoning, because telescope proposals aren't the only place where selection processes are biased against women and other under-represented groups, stunting their career opportunities.

"Once you see these results from Hubble, I just don't see how there could be any other way of doing things," says Johnson. "It just seems so clear that we need a change." ■

APERTURE





Ultimate test kitchen

THIS is the Future Consumer Lab. It might be in Denmark, but *hygge* it isn't. The Danish word means comfort, cosiness, well-being and simplicity - while the vibe here is more Heston Blumenthal meets *Brave New World*.

But hang on. Set up by Wender Bredie at the University of Copenhagen's Department of Food Science, the lab's goal is to understand the interaction between people and food in order to encourage eating behaviours that are healthy, individualised and more sustainable. The team analyse the components of foods that contribute to taste and smell, and measure how context and environmental enrichment change sensory perception and emotional response.

To do this they need controlled surroundings. They also utilise virtual reality, as in this main image, where the woman is sampling food in the lab but sees and hears a restaurant in the south of France, with black-tie waiters bustling around and the sound of the sea in the background.

The research has real-world applications, such as designing appetising foods for older consumers or stimulating eating in malnourished patients. "These principles will be translated to kitchens and 3D food printers at hospitals," says Bredie. He hopes such work will empower patients to choose healthy dishes they enjoy eating, rather than being served those other people think they like.

Another strand of research at the lab is to design foods so that they are eaten in smaller amounts. This might mean flavours that induce subtle "oral irritation" so as to prevent overconsumption. So the lab itself might not seem very *hygge*, but well-being and contentment are central to its aims. Rowan Hooper

Photographer

Alastair Philip Wiper

alastairphilipwiper.com

APERTURE



Clockwise from above:
In the physiology lab a woman smells different food odours while her brain activity is recorded; food is sampled in special test booths; CCTV allows staff to watch volunteers; a Sniffin' Sticks test kit is used to evaluate sensory recognition in older people.





COVER STORY

If you want to stick to your resolutions, it helps to be sure they are worthwhile. **Linda Geddes** dives into the relevant research to reveal five things you should start doing this year – and five you should stop

HAPPY NEW YOU

START EMBRACING NATURE

In the Shetland Islands, off the north coast of the UK, doctors are handing out some unconventional prescriptions. Along with regular therapies, people with a range of physical and mental ills are being told to take in the sounds and smells of seabird colonies, build woodland dens or simply appreciate the shapes of clouds. A similar scheme in New Zealand found that, six to eight months after receiving a “green prescription”, two-thirds of patients were more active and felt healthier, and almost half had lost weight. Meanwhile, so-called eco-therapy, which involves participating in outdoor activities such as gardening or conservation, is emerging as a promising treatment for mild to moderate depression.

In fact, we have long recognised that people living in greener neighbourhoods tend to have better cardiovascular health and lower levels of stress, regardless of their socio-economic

status. Recent research also suggests that city dwellers living near green spaces are at lower risk of type 2 diabetes. And it seems the greater the biodiversity in green spaces, the larger the benefit to our psychological well-being.

Various explanations have been proposed for such findings. Simply being outside boosts exposure to bright light, which is known to be an effective treatment for both seasonal and non-seasonal depression (see “Start brightening up your day”, page 29). Then there are the benefits of exercise, social contact and time out from everyday problems. Yet, connecting with nature seems to provide additional physical advantages. “We know that our heart rate slows down, we are less stressed, we breathe better and our immune responses are improved when we are in green space,” says Rachel Stancliffe of the Centre for Sustainable Healthcare in Oxford, UK. “Although we don’t completely understand

those things, we think it is related to a reduced stress response, which is partly a mental and partly a physical thing.”

Some people believe that having evolved alongside nature, we possess an instinctive urge to seek out and respond positively to it. Even exposure to nature in the form of images of natural scenes or recordings of birdsong can reduce heart rate and blood pressure, enhance attention and distract from pain. One study found that diffusing pine oils into people’s bedrooms while they slept led their bodies to produce more natural killer cells, which fight viruses and cancers.

Regardless of the mechanism, getting outdoors is good for you. Add a social and physical element – by joining a hillwalking group or volunteering at a community allotment (see “Start helping others”, page 29), for example – and the benefits will be heightened. What could be more natural? ➤



MICHELE MARCONI

START LEARNING A NEW LANGUAGE

At this time of year, many people's thoughts turn to physical exercise to work off the excesses of the festive season. But mental exercise is equally important. So, what is the best way to hone your mind, improve your thinking skills and help stave off cognitive decline as you age?

Puzzles and brain-teasers are a popular choice, but somewhat lacking. "The problem with things like crosswords and sudoku is that they aren't very varied," says Thomas Bak at the University of Edinburgh, UK. "It is like going to the gym and using only one machine: your biceps might become strong, but you won't be properly fit."

To get a bigger bang for your buck, you need something more like circuit training or parkour. That is why one of your best options is to tackle a foreign language. This will provide a mental workout comprising many different skills, from perception to the suppression of your native tongue to learning grammatical rules, which can be almost mathematical. If you speak to others, you get the bonus of social interaction too.

Learning a new language may be hard work, but the payoff is impressive. For a start, it can improve your mental focus. Following an intensive, week-long Gaelic course, people were better at paying attention and suppressing irrelevant information. The effect gradually wore off, however, if they didn't stick with their language practice.

Other studies indicate that people who are bilingual have improved executive function – the ability to plan, organise and complete tasks – although these results have recently been disputed. There is also evidence that they develop dementia four years later, on average, than people who are monolingual – and that they recover faster if they have had a stroke.

If languages really aren't your thing, you might consider taking up a musical instrument or joining a choir, instead. Music training utilises many of the same skills as learning a language, and has been associated with improved memory, attention and empathy. It may even improve your ability to acquire new languages.



GUOXULE/XINHUA/EYEVINE

START CUTTING BACK ON ALCOHOL

No doubt, you have heard of Dry January. The idea is that by foregoing all booze for a whole month, you make amends for recent excesses and reset your relationship with alcohol. It is a neat challenge. But is it worth the effort?

In the short-term at least, it appears to have health benefits. A recent study of moderate to heavy drinkers who had stayed sober for a month recorded a significant drop in insulin resistance – suggesting their risk of developing type 2 diabetes went down – as well as reductions in blood pressure, cholesterol and two growth factors associated with the development of cancers.

Whether Dry January changes long-term behaviour is less clear, however. Only one study has directly assessed this. It found that people who completed the challenge claimed to be consuming less alcohol six months on: the average number of days per week on which they had a drink had fallen from 4.7 to 3.7, and the number of drinks they consumed each time fell from 3.7 to 3.1. However, 36 per cent of participants failed to complete the challenge, and for this group, the reduction in alcohol

consumption at six months was smaller. These results may not be representative either, as three-quarters of participants didn't complete the six-month follow-up survey.

"Overall, I think that initiatives like Dry January are a good thing because anything that gets people thinking about their relationship with alcohol is positive," says Ian Hamilton at the University of York, UK, who specialises in substance abuse. "The problem is that – even if they achieve the month's abstinence – it kind of lets them off the hook for the rest of the year. I would much prefer for people to go through January drinking, but committing to having at least two consecutive days a week drink-free, which would be easier to sustain."

Going "damp" rather than "dry" gets support from research published in August suggesting that a drink a day might help ward off dementia, because small amounts of alcohol stimulate the system that flushes toxins out of the brain. But the same month, a large and widely reported study in *The Lancet* concluded that there is "no safe amount of alcohol". It calculated that consuming even one drink a day – equivalent

START BRIGHTENING UP YOUR DAY

You may not realise it, but you are probably light deprived. The intensity of light is measured in lux. Standard office lighting tends to be around 200 lux. Even on an overcast winter's day, it is around 10 times brighter outside, and on a sunny summer's day it is up to 500 times brighter. Yet, the average Westerner spends around 90 per cent of their time indoors. This is a problem.

Bright light stimulates your brain, boosting alertness and reaction times. It strengthens our circadian rhythms, the 24-hour fluctuations in our biochemistry and behaviour that enable us to perform optimally around the clock. Spending much of the day indoors – along with exposure to artificial light long after sunset – can subdue these rhythms, disrupting sleep and increasing the risk of conditions such as depression and dementia. Light also affects our moods, so much so that bright light is used to treat seasonal affective disorder (SAD), and exposure to it soon after waking is

as effective for general depression as antidepressant drugs.

One obvious solution is to spend more time outdoors, particularly in the morning when your circadian clock is most responsive to the effects of light. If that isn't an option, special lighting can help. German researchers found that people exposed for 3 hours during the morning to bright, blue-enriched light (of the sort you get from a lamp designed to treat SAD) improved their reaction times, suggesting they were more alert, both at the time and for the rest of the day. The light also appeared to lessen the effects on sleep and circadian rhythms of being exposed to artificial evening light. All good reasons to brighten up your life.

“Bright light stimulates your brain, boosting alertness and reaction times”

to 10 grams of alcohol or 1.25 UK units – increases people's risk of developing one of 23 alcohol-related diseases by 0.5 per cent. And the risk rises steadily the more you drink.

That is sobering. But nothing in life is without risk, says statistician David Spiegelhalter at the University of Cambridge. Even the authors of *The Lancet* paper consider that figure “neither practically nor statistically significant”, he notes. It means that 25,000 people would need to drink this amount for one additional person to develop such a disease each year. “Even if you did believe that number, many people might feel that one drink a day is worth the totally trivial risk – just as many feel it's worth driving a car or getting out of bed in the morning,” says Spiegelhalter.

He argues for the promotion of two alcohol thresholds: a low-risk one at around 14 units a week, and a high-risk one at around 50 units for men and 35 for women. “At that level, there's about a one-in-eight chance that alcohol will kill you,” he says. A sober resolution would be to get as close as possible to the lower threshold – and ideally below it.



START HELPING OTHERS

The essence of life, wrote Aristotle, is to serve others and do good. Make this the basis of a New Year's resolution and you will be doing yourself a favour too.

It turns out that people who volunteer are happier and healthier on average than those who don't. You can get these benefits by giving time to a cause you care about, whether related to the arts, the environment, politics or whatever. However, the biggest boost comes by doing work directly focused on helping others.

It may seem counter-intuitive, but taking on extra responsibilities can reduce stress. Consider, for example, a study by Rodlescia Sneed, now at Michigan State University, and Sheldon Cohen of Carnegie Mellon University. They took blood pressure measurements from around 6700 people aged over 50, then simply let these people get on with their lives for four years before taking another measurement. What she and Cohen wanted to find out was whether volunteering would make a difference and whether more volunteering would provide even more benefits.

The results were conclusive. Compared with non-volunteers or those who had done less than 200 hours of voluntary work in the preceding two years, more active volunteers were 40 per cent less likely to have developed high blood pressure. One possible explanation is that volunteering takes your mind off your own troubles and may provide a sense of perspective. Another is that altruistic behaviour triggers the brain's reward circuitry and the release of the “bonding” hormone oxytocin, both of which can reduce stress. “Stress is very much linked to high blood pressure,” says Sneed.

There is even more to be gained by helping others as we age. Sneed recently found that people who help care for their grandchildren stayed mentally sharp for longer than their counterparts. She believes social interaction is the key here.

“There is a lot of evidence that people who have lots of social interaction, or are more socially engaged, have better health outcomes,” she says. “Also, when you are doing something productive, such as contributing to an organisation with volunteer work or helping to take care of your grandchildren, that can provide you with a sense of meaning or purpose, which is another thing that seems to really have positive outcomes for health.”

STOP YOUR GYM MEMBERSHIP

Get more exercise! It is the New Year's pledge that tops many people's list. While it is a good one, joining a gym might not be the best way to achieve it. "We may need to allocate more time towards being active throughout our day, rather than just checking a box saying we've exercised for 30 minutes," says Keith Diaz at Columbia University in New York.

If you have a desk job – or couch-potato tendencies – this applies to you. Diaz and his colleagues found that adults who regularly sat for 1 or 2 hours at a time had a higher risk of early death than those who spent the same overall amount of time sitting, but who got up and moved every half hour or so. One reason is that our muscles help regulate blood sugar levels, but need to be active to do so. Prolonged sitting can also cause blood to pool in the legs, which can damage blood vessels.

Interspersing your day with movement, therefore, seems to be important. But how much is necessary? "Even 1 minute of exercise is enough to prime the muscles and get them contracting and perhaps offset some of the harms of sitting," says Diaz. However, the more you do, and the more vigorously you do it, the better. His team found that every 30 minutes of

sitting that is replaced with light, physical activity reduces your risk of early death by 14 to 17 per cent. Vigorous exercise lowers it by around 36 per cent.

"Probably the optimal strategy would be to intersperse sitting with some movement, but also get in some exercise at the beginning or end of the day," says Diaz. This could be done by, say, cycling to work and back, and ensuring you briefly leave your desk every 30 minutes, or even doing some heel raises while sitting.

Another option, if your work environment allows, would be to break up your day with 5 to 10-minute bursts of more vigorous exercise every half hour or so. By the end of the day, you would have completed the equivalent of a gym workout, without setting foot in a gym. Physiologists used to believe that for physical activity to be beneficial it had to occur in bouts lasting 10 minutes or more, but they are increasingly backtracking, says Diaz. A November update to the *Physical Activity Guidelines for Americans* emphasised that any activity is beneficial. "So many people fail at doing the exercise thing for their New Year's resolution," says Diaz, "so this might be a different twist on your endeavours to become more active."

STOP OVERCONSUMING

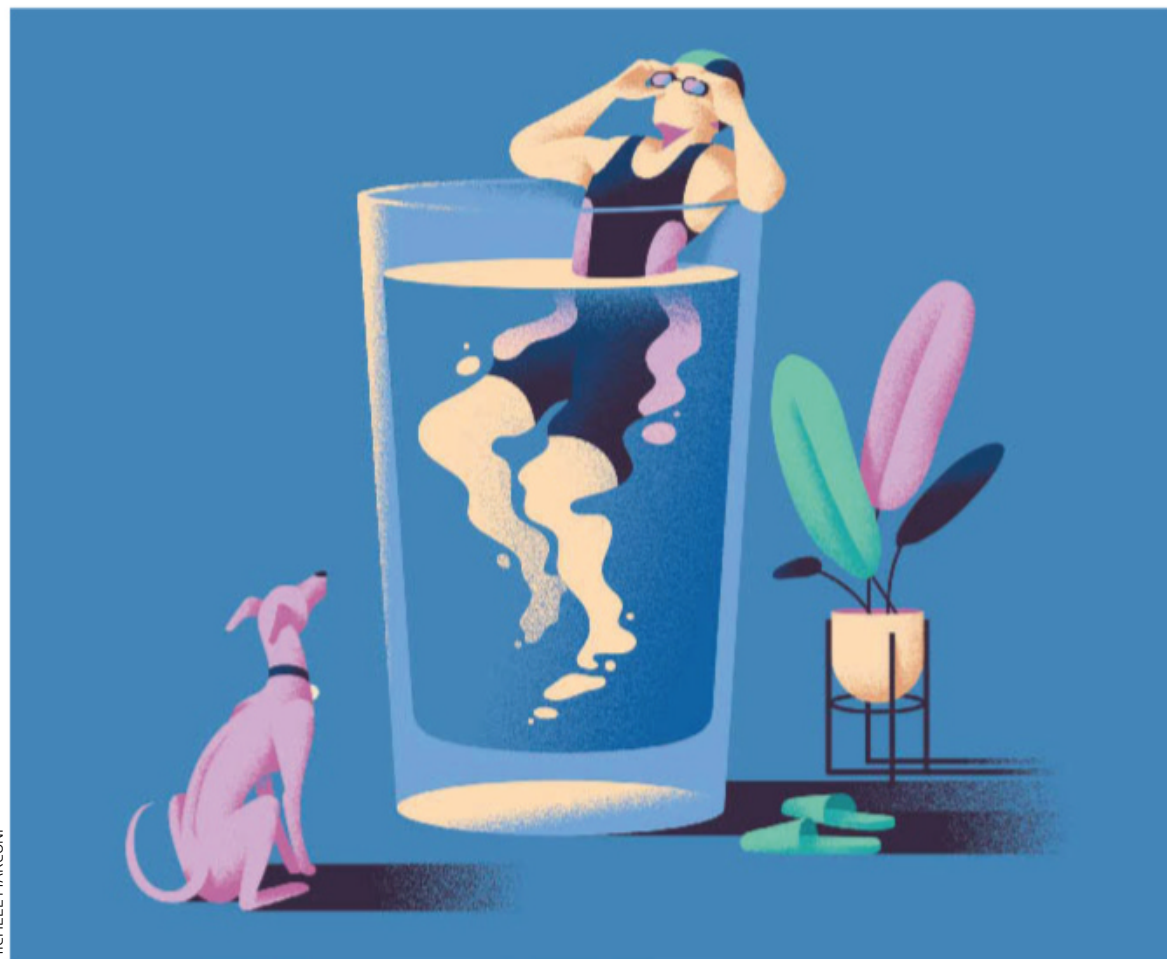
Consider a toaster. To make the metal and plastic components it contains, raw materials must be extracted from the ground, melted or heated, purified and modified, then transported to a factory, or maybe several, to produce the different parts. Once they have been assembled and packaged, the final toasters must be transported again.

No wonder our insatiable appetite for new things consumes so much energy. "A sizeable chunk of our overall carbon and biodiversity footprint comes from just the stuff that we buy week in, week out," says Mike Childs, director of research at Friends of the Earth UK. "Buying stuff comes in at around 44 kWh per day per person, plus 12 kWh to transport it all," he says. A whopping 14 kWh per day of this is associated with producing your car. Packaging contributes around 7 kWh a day. By comparison, an average Westerner uses around 20 kilowatt-hours (kWh) of energy each day to heat their home. And if you spread the energy cost of taking a long-haul flight across a whole year, it works out at around 30 kWh a day.

Clearly, we need to buy some stuff, but we can reduce our impact. "Buying more durable products means you will be buying replacements less often, as does repairing items rather than putting them in the bin," says Childs. Buying second-hand or refurbished items is another good strategy.

What about food? The typical energy costs of food, farming and fertiliser come in at 15 kWh per person per day, says Childs. This is in addition to the other things we buy. Reducing meat consumption is an obvious first step because raising and feeding livestock is so energy-intensive. Cutting food waste could have a big impact too. If food waste were a country, it is estimated that it would have the third-largest carbon footprint, behind the US and China.

That is not all. "Agriculture is the single largest threat to global biodiversity, with large amounts of the tropics being cleared to produce food, often for export," says Erasmus zu Ermgassen at the Catholic University of Louvain (UCL) in Belgium. "Any dent that food waste reduction makes in the demand for food is therefore a huge benefit, not just in carbon emissions, but in land and water consumption." It could also save you money – another popular New Year's resolution. Although, if you want to do the right thing by the planet, resist the urge to spend what you save on more stuff.



MICHELE MARCONI

STOP LATE-NIGHT SNACKING



BRYCE LANKARD/GETTY

Increasingly, it seems it is not just what you eat, but when you eat it that matters. So, if you are struggling to lose weight, or simply want to strike a healthier relationship with food, consider imposing a time limit on your biscuit tin.

The way we process and metabolise food varies across the day, due to 24-hour rhythms in our liver, pancreas, muscles and even our fat cells. Generally, we are better equipped to handle food consumed during the daytime, which makes sense given this is when humans have evolved to be active. Several studies have associated late-night eating with an increased risk of diabetes and obesity. Why should this be?

In a recent study, Marta

Garaulet at the University of Murcia, Spain, and her colleagues compared what happened when the same group of people ate their dinner 4 hours before their habitual bedtime, or an hour before it. Even though they had exactly the same meal, eating later resulted in impaired glucose tolerance – a prediabetic state associated with higher-than-normal sugar levels in the blood.

The reason may be melatonin, a hormone we begin to secrete in the evening and continue to release overnight, telling our various organs and tissues to gear up for the night shift. "We think that if you have food together with melatonin, you may have impairments in glucose control or metabolism," says Garaulet. Supporting this idea,

her team found that people with a genetic variant resulting in receptors that are more sensitive to melatonin had higher glucose intolerance when they ate meals not long before going to bed.

If weight loss is your goal, then besides avoiding late-night snacking, you might also reconsider your attitudes to daily meals. In a previous study, Garaulet found that when women were put on a weight-loss diet, those who ate the bulk of their calories before 3 pm lost around 25 per cent more body mass than women who consumed the same number of calories but ate more of them later in the day.

The adage that one should breakfast like a king, lunch like a prince and dine like a pauper has never seemed truer.

STOP SCRIMPING ON SLEEP

According to the National Sleep Foundation, most adults need between 7 and 9 hours of sleep each night. If you are failing to notch up the recommended hours, consider the consequences. Lack of sleep causes accidents: driving on less than 5 hours' sleep trebles your risk of having a car crash, for instance. It has been linked with pretty much every major disease going, from heart disease to diabetes to cancer. It interferes with your attention, working memory, organisation and time management. It reduces your ability to fend off infection. It makes you hungry, so you are more likely to overeat. And it affects your mood, leaving you feeling irritable and at greater risk of depression.

The good news is that you can avoid all of this with one (seemingly) simple resolution: go to bed earlier.

You may see yourself as an owl, but if you don't feel sleepy until late, one cause could be artificial light. Several studies have shown that when people are camping, which removes much of the artificial light from their evening, their body clocks shift several hours earlier.

The knock-on benefit is that they also feel sleepy sooner and get more shut-eye. When camping, it tends to be cooler too, which is another thing to consider, because your core body temperature needs to drop to initiate sleep.

To recreate the sleepy camping environment while enjoying the comforts of home, embrace candles, dimmable light bulbs and those that can be adjusted to produce a warmer light, along with apps that filter out blue light from computer and smartphone screens. Lower the thermostat in the run-up to bed: between 16°C and 18°C is considered optimal. Also, if your insomnia is related to stress, perhaps resolve to avoid all work calls and emails in the 2 hours before bed. And, of course, make sure you aren't hopped up on caffeine or alcohol.

Once you have set an earlier bedtime, try to stick to it. Constantly changing your routine is like imposing jet lag on your body – and this isn't conducive to sleep. So, try to wake up and go to bed at regular times to strengthen your circadian clock and control when you feel sleepy and alert.



PLAINPICTURE/JOHNER/SUSANNE WALSTROM

STOP BEING SO HARD ON YOURSELF

If you break your resolutions before January is even out, cut yourself some slack. There is huge variation in the amount of time it takes people to form a new habit: the average is 66 days, but it can take almost an entire year. So, if at first you don't succeed, relax and give it another go. You don't have to wait until 2020 to try again. ■

Linda Geddes is a consultant for *New Scientist* and author of *Chasing the Sun: The new science of sunlight and how it shapes our bodies and minds*, published next week

Green sky thinking

Our flying addiction is ruining the climate. But exciting new tech is on the way to fix that, reports **Paul Marks**

RIGHT now, there are more than half a million people in the sky. Some 11 kilometres up, at the base of the stratosphere, the equivalent of a small city's population is strapped into seats in pressurised tubes atop gigantic tanks of kerosene. It is an extraordinary thought.

It is also a worrying one. By some estimates, aviation is set to become the single biggest source of carbon dioxide. You may have switched to a green energy supplier, swapped your car for a bike, and maybe even stopped eating meat. But if you're thinking about taking that holiday in the Mediterranean and don't want to bust your carbon budget, you're going to have to paddle there.

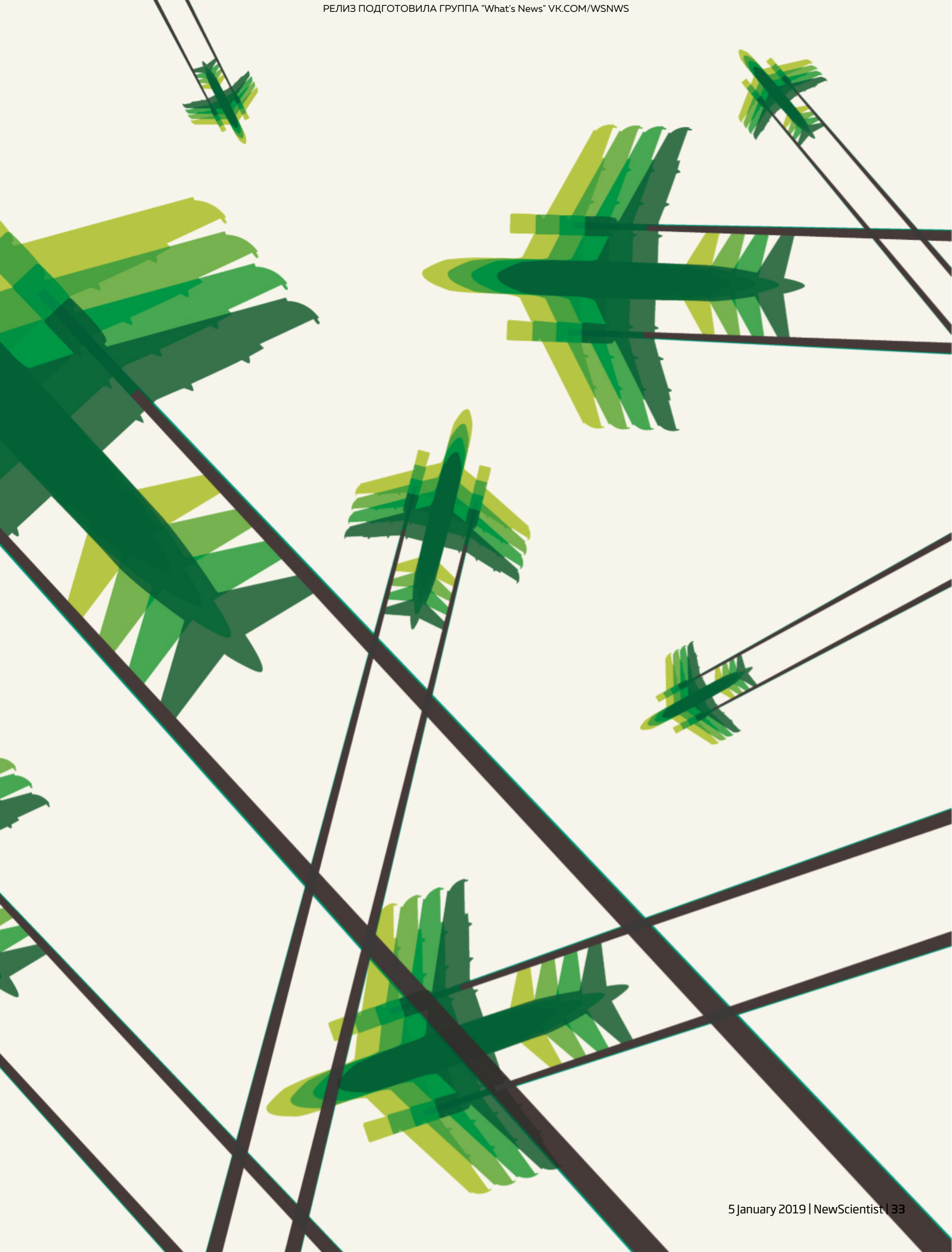
Yet we are addicted to flying. Few would willingly give up the freedom and opportunities it gives. So is there any way we can keep that city in the sky aloft without destroying the planet?

One factor that makes it especially tough is the ever-increasing number of us up there. An average return plane ticket in 2017 was about 60 per cent cheaper in real terms than it was in 1995. That has driven an annual 5 per cent rise in passenger numbers. At the moment, 4 billion passenger seats are sold in

civilian airliners each year, according to the International Air Transport Association. By 2036, that figure is predicted to almost double to 7.8 billion. That means annual passenger numbers in roughly 20 years will be a shade higher than Earth's entire population today.

At the same time, aviation's emissions of potent greenhouse gases like carbon dioxide and nitrogen oxides will increase. Flights currently account for about 2 per cent of anthropogenic CO₂ emissions. By 2050, estimates suggest that the figure could be 10 per cent. It could even be 20 per cent or more if other sources of pollution like road transport cut their emissions, a prospect that looks likely as countries begin to set deadlines that mandate a shift to electric cars (see diagram, page 35).

All this makes aviation a critical challenge in fighting global warming. Yet unlike road transport, international aviation has escaped the bite of environmental accords like the UN's Paris Agreement. Domestic flights are covered by the Kyoto Protocol, but represent a tiny proportion of emissions. International flights, however, cross borders, which has made it difficult to agree who is responsible for cutting their emissions. ➤

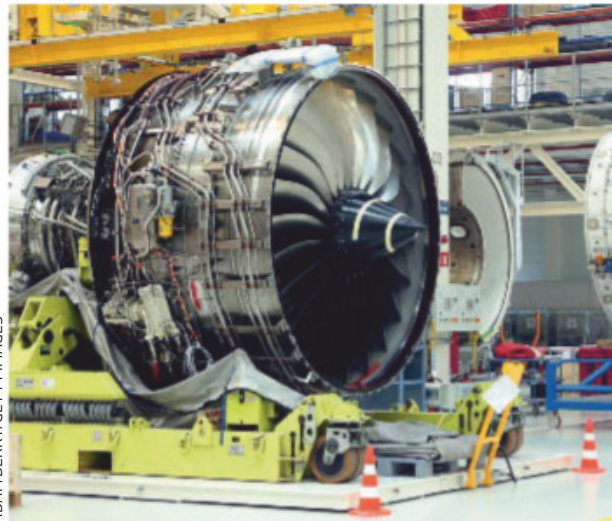


Jet engines get just a little more efficient each year

An agreement was finally reached in 2016, when the UN's International Civil Aviation Organization brokered the first global deal to curb emissions. The linchpin is the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). This aims to keep the industry's net emissions static beyond 2020 by requiring airlines to buy carbon credits, which pay for measures that reduce the amount of CO₂ in the atmosphere, like planting trees.

At aircraft manufacturer Airbus in France, head of environmental affairs Hubert Mantel says he is encouraged by the programme's uptake. Some 72 countries have signed up to the voluntary scheme, meaning it covers more than 75 per cent of today's CO₂ emissions from international aviation, he says. "It's a remarkable start, and more countries are hopefully going to join."

But plenty of people see it as not nearly radical enough. For instance, China, where major passenger growth is expected, hasn't signed up, and last month the European Union formally objected to the scheme. The deal also allows airlines to emit as much as they like as long as they offset it with financial instruments. "It's not driving innovation in emissions reduction in the aviation system as



ADAM BERRY/GETTY IMAGES

a whole," says John Broderick, who studies climate policy at the University of Manchester, UK. So what practical measures could we take and how effective might they be?

FLY IN STRAIGHT LINES

One way to reduce emissions would be for planes to actually fly in straight lines. Air traffic travels along flight corridors that zig and zag to enter and exit nations' airspaces at a few fixed points. This is a legacy from decades ago when planes flew from waypoint

to waypoint so as to stay within range of radar.

Flight corridors are gradually being swept away by a new approach, called free route airspace, enabled by technologies like GPS and constant satellite tracking of planes. Each flight publishes its planned route in advance, then, as long as air traffic controllers monitor traffic, they can avoid clashes.

Morten Grandt, an engineer developing this system with German air traffic control, says the increase in route choice lowers aircraft density, meaning less noise under flight corridors and an even lower crash risk. It is as if the planes all take a different country lane rather pile onto the motorway.

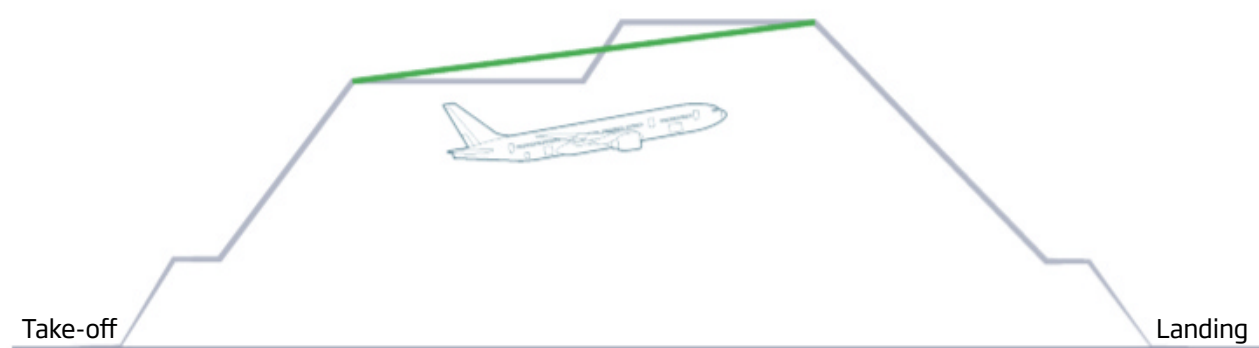
The approach is already taking hold in Europe and the US. Eurocontrol, an intergovernmental organisation developing a Single European Sky programme that will see free route airspace in effect across Europe, says most member countries should be operating it by the end of 2019. The US Federal Aviation Administration (FAA) is working on a similar set-up called the Next Generation Air Transportation System. It says this will be part of the mix of measures that will help cap emissions beyond 2020.

How much carbon would flying straighter save? Eurocontrol calculations suggest free route airspace will prevent 150,000 tonnes of CO₂ per year being emitted in Europe. That is the tiniest sliver of global aviation emissions, which were 859 million tonnes in 2017.

Freeing pilots to fly as they see fit more broadly, however, could make a big difference to emissions, says Craig Lawson, an aviation systems designer at Cranfield University, UK. "The optimum way to cruise for minimum fuel burn is what's called a cruise climb," he says. Aircraft get lighter as they consume fuel and so can stay aloft with the reduced lift provided in thinner air. Because that air provides less drag, higher cruise altitudes are more efficient too, so airliners should drift upwards as they fly, instead of ascending in steps (see diagram, left). Lawson says cruise climbs could save aircraft 10 per cent of their fuel.

Just cruising

Commercial flights normally **climb in steps** as directed by air traffic control. But a smoother **cruise climb** would be more fuel efficient



SOURCE: CRAIG LAWSON, CRANFIELD UNIVERSITY

Making Europe's flight corridors straighter could save **150,000** tonnes of CO₂ per year

But global emissions from aviation in 2017 were **859 million** tonnes

So the plan would only reduce emissions by **0.02%**

MAKE PLANES SLEEKER

Noodling with flight paths can cut some carbon, but we can probably save more by making planes slice through the air more efficiently. History certainly suggests so. The engines on a new Airbus A350 produce 15 per cent less CO₂ for the same thrust than those of an Airbus A330 delivered in 2000, says Paul Stein, chief technology officer at Rolls-Royce Aero Engines, UK. That trend



holds generally: for about the past decade, innovations have tended to make aeroplanes about 1 per cent more efficient every year.

There is every sign that will continue in the short term. For example, giving planes longer wings increases their lift and reduces the fuel they need to stay aloft. Boeing's forthcoming 777X jet has wings that are so long they do not fit in standard airport gates, but their tips will fold up to get around this snag.

Unfortunately, innovations like this don't add up to much. Just contrast that 1 per cent per year efficiency saving with the expected annual 5 per cent growth in passenger numbers. Plus, as Doug Parr, chief scientist at Greenpeace, points out, many airliners are in service for decades, so fuel-saving innovations aren't used straightaway. Something more drastic and more immediate is needed.

The International Council on Clean Transportation, a non-profit organisation in Washington DC, has suggested that a return to propeller aircraft could be the thing. These have a much higher fuel economy. Aircraft like the Canadian Bombardier Q400 are the workhorses of short flights in many parts of the world, but they are slow. "It's true, if you slow down you will burn less fuel," says Lawson. "But making journey times longer, especially on long-haul flights, is not going to be welcome."

MAKE CARBON-NEUTRAL FUEL

If we can't get planes to use dramatically less fuel, maybe the stuff they burn could be greener. Most planes run on Jet A, which is basically kerosene, an oil-derived chemical composed of carbon and hydrogen. But make the stuff using carbon from greener sources, and you would be on to something.

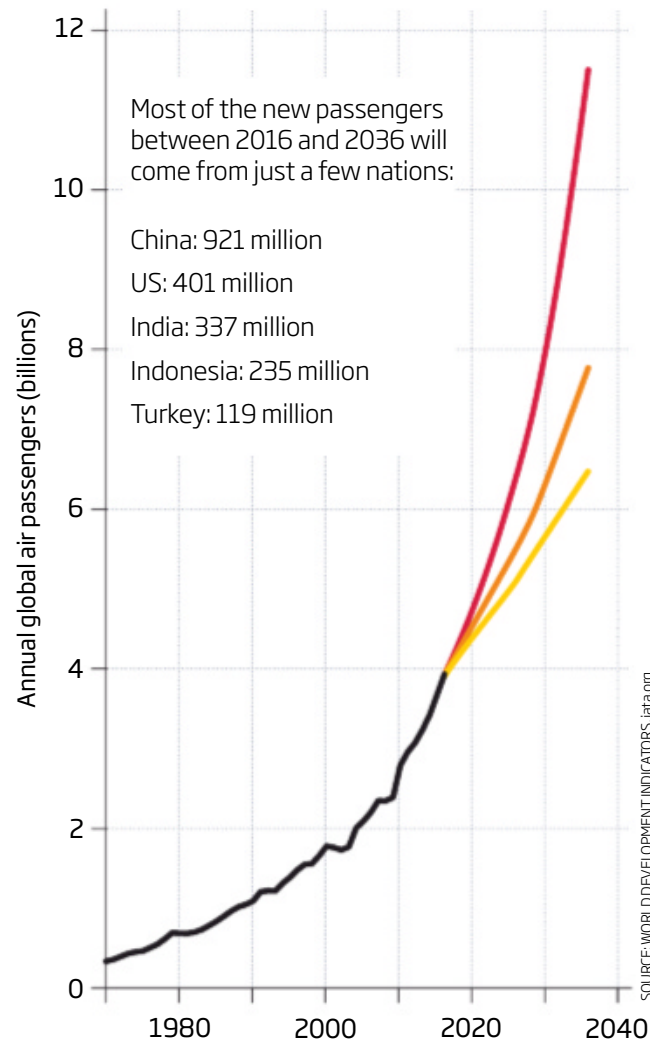
Joris Melkert at Delft University of Technology in the Netherlands began exploring this a decade ago. Kerosene from oil contains a range of low-level impurities that are thought to help the engines run smoothly, for example by swelling their rubber seals. In 2008, Melkert began testing whether synthetic fuels, which would contain fewer impurities, would still be safe. Soon afterwards, he flew a test jet with a fuel made from 95 per cent synthetic kerosene.

That fuel was synthesised from natural gas, but, in principle, synthetic kerosene from any source would be safe. That prompted ASTM International, which sets the standards on jet fuel, to rule that blends of up to 50 per cent synthetic kerosene could be used on flights. That in turn got the airline industry developing synthetic kerosene from crops.

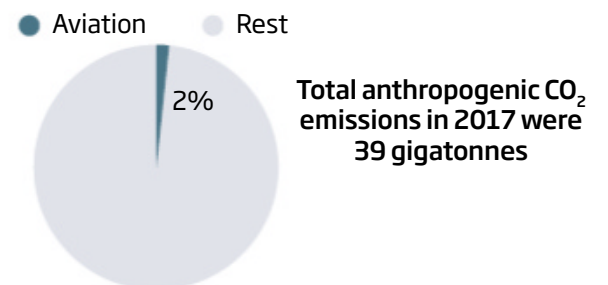
Flying high

There are ever more air passengers and growth could accelerate depending on how policies change in the coming decades

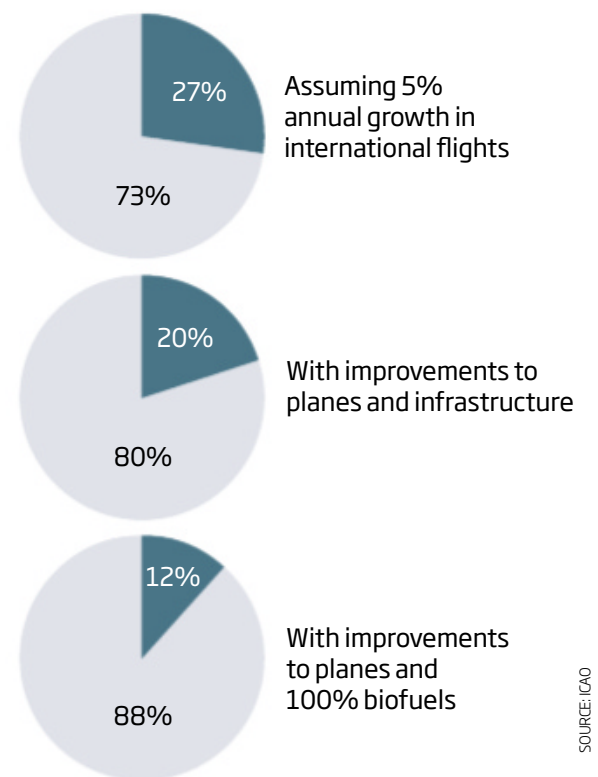
- Immigration and trade policies are liberalised
- Policies stay roughly the same
- With restrictions on flight numbers



At the moment, aviation is responsible for a small proportion of total CO₂ emissions



But if other sectors cut their emissions according to current commitments, aviation will have a larger share of the target total carbon budget of 205 gigatonnes up to 2050, even with green innovations



Jets are allowed up to **50%** biofuel in their tanks

In the past decade, **143,000** flights used a biofuel blend

That's a fraction of the **39 million** scheduled flights in 2018 alone

Biofuels have the potential to slash emissions, with some flights highly publicised to get the message across. In September 2018, an Airbus A320 was delivered from Mobile, Alabama, to the JetBlue airline in New York, flying with a 15 per cent blend of biofuel. But the overall impact has been modest. Sean Newsum, director of environmental strategy at Boeing Commercial Airplanes, says 143,000

passenger flights have used biofuel blends in the past decade – not many compared with the 39 million scheduled flights in 2018.

Even if biofuels were widely used, there is concern over the impacts of growing the feedstocks. Would it displace food crops? And how much carbon is emitted generating the energy used to turn crops into fuel? Newsum says Boeing has a number of projects

A short hop

Planned hybrid electric planes are likely to have a range of only about 1100 kilometres. Here is where that could get you from three major cities



investigating the best sources of biofuel, including forestry waste in Canada, nicotine-free tobacco in South Africa and seawater irrigated plants in the United Arab Emirates. These all produce small amounts of fuel.

Better would be to make a synthetic fuel using carbon sucked from the air, so no net carbon is released when it is burned. This was first demonstrated by a company called Air Fuel Synthesis in 2014. In June 2018, a Canadian firm, Carbon Engineering, showed that it had got the cost of removing 1 tonne of CO₂ from the atmosphere down to between \$94 and \$232, at least a third cheaper than previous estimates. But the challenge is to emit less carbon making the fuel than you save by avoiding oil-derived kerosene. And that's tough. Tellingly, Air Fuel Synthesis quietly folded in 2016.

BUILD ELECTRIC PLANES

In June last year, Norway's transport minister strapped himself into a small, white aircraft beside the CEO of Avinor, the state-owned company that runs the nation's airports. They

wobbled into the air, buffeted by winds, and took a few laps around Oslo airport. The stunt was to underline Norway's pledge that all domestic flights will be fully electric by 2040.

Electrifying aircraft is the sort of step that really could make a serious dent in emissions. Were planes to be run on batteries charged with electricity from renewable sources, flight could be almost carbon neutral.

However, the plane flown in Norway was just a two-seater. No one has yet managed to power an airliner on electricity, though some are trying. One of the most ambitious schemes is the E-Fan X project from Airbus. The firm is working with electric motor-maker Siemens, and Rolls-Royce, on converting a four-engine jet into a hybrid-electric plane, where one engine is replaced by an electric fan. A small engine hidden inside the plane will charge the batteries that run the electric motor, "like a Toyota Prius in the sky", says Stein. The plan is for a test flight in 2020.

Likewise, Boeing is investing in Zunum Aero, a start-up aiming to build a 50-seat hybrid plane by 2022. The firm claims its

plane will burn half the fuel of a similarly sized standard jet. The big drawback is that planes like this would have fairly meagre ranges, at least with today's battery technology. Zunum reckons its planes will manage about 1100 kilometres on a single charge (see diagram, above).

However, if electric planes do take off, it could transform the way we travel. Electric aircraft wouldn't just been green, they would be cheap and quiet. This could finally make personal aerial vehicles – otherwise known as flying cars – a reality. In the long term, these might even replace commuter trains, often considered relatively green.

It might come sooner than you think. German firm Volocopter has been developing an electric vertical take-off and landing (eVTOL) aircraft that has a cabin suspended beneath a ring of several rotors. The firm plans a test flight of its two-person machine in Singapore this year, the first in a built-up environment. Meanwhile, the EU has begun a consultation on standards needed to certify eVTOLs, while NASA and the FAA are hammering out similar regulations.

Large passenger planes that fully avoid kerosene are a long way off though, barring a huge tech breakthrough. Paul Peeters, a former aviation engineer now researching sustainable transport at the University of Breda in the Netherlands, has analysed the battery requirements of a 60-seater electric aircraft. "The battery, with current lithium technology, would have to be literally bigger than the whole aircraft," says Peeters.

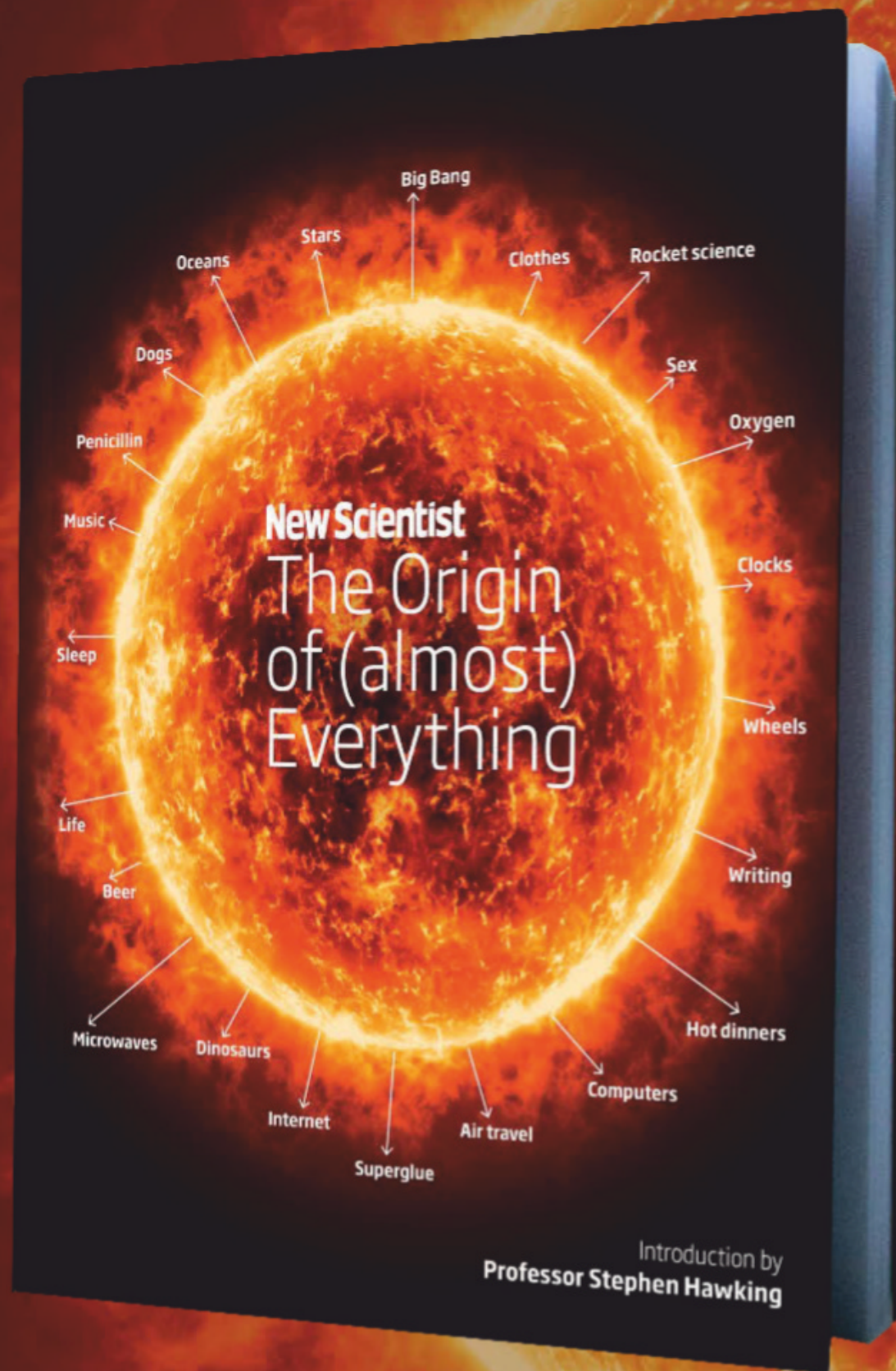
He thinks the only solution is to find a way of limiting the number of flights, perhaps through an international agreement that goes far beyond what the UN has brokered so far. "We cannot count on these measures," he says. "It is way too late." ■

Paul Marks is a technology journalist based in London



The Alpha Electro G2 plane runs entirely on batteries. But with two seats, it is no airliner

Where did we come from? How did it all begin?



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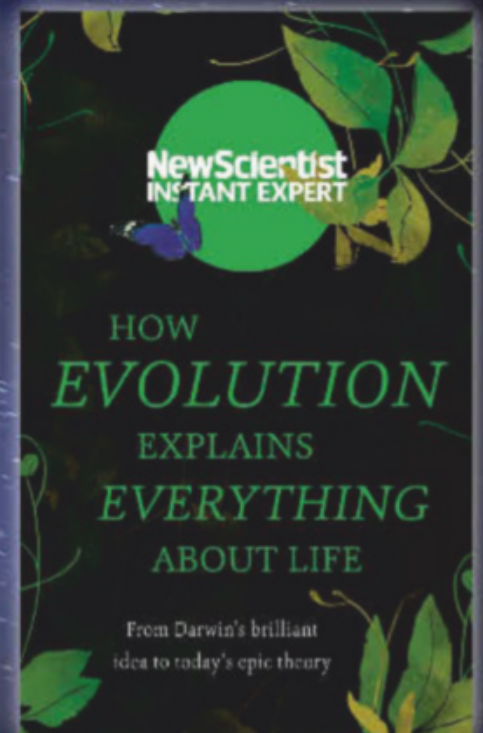
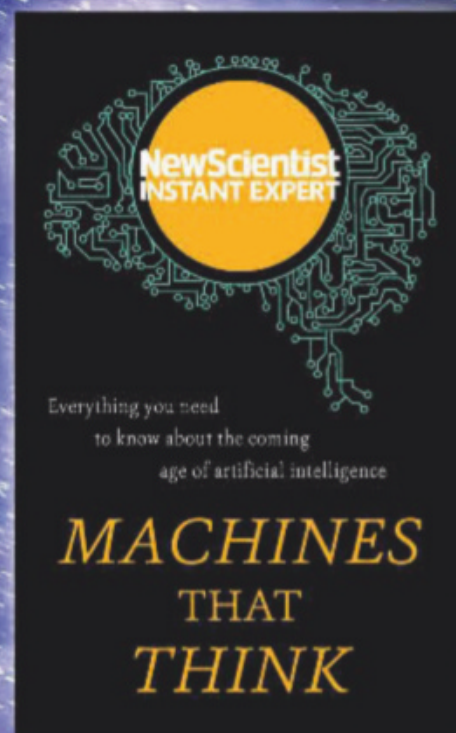
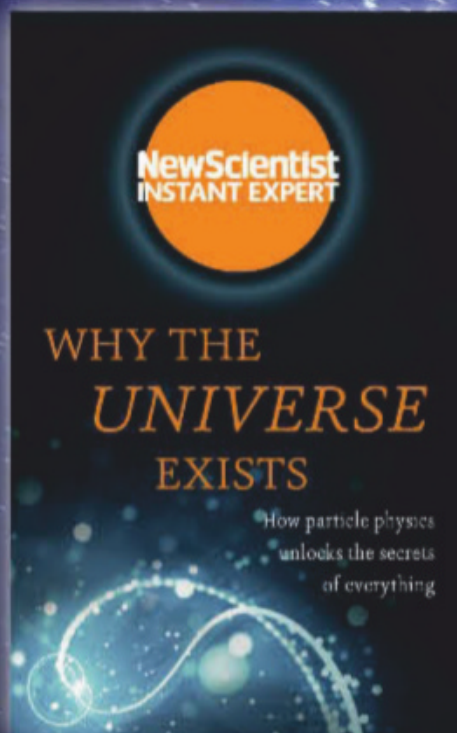
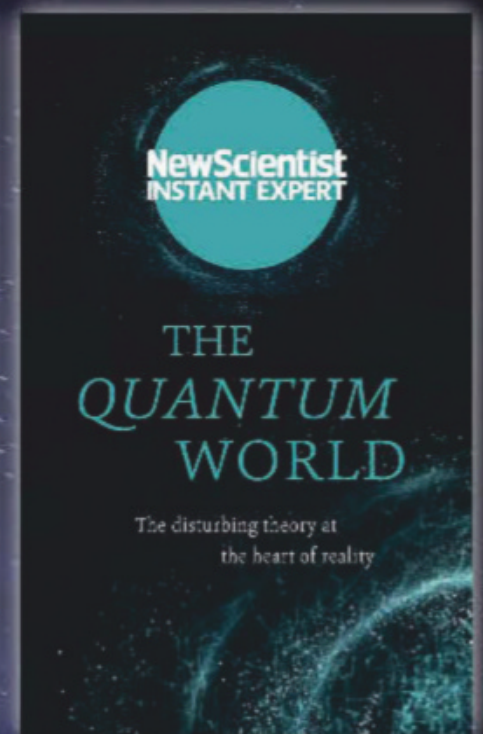
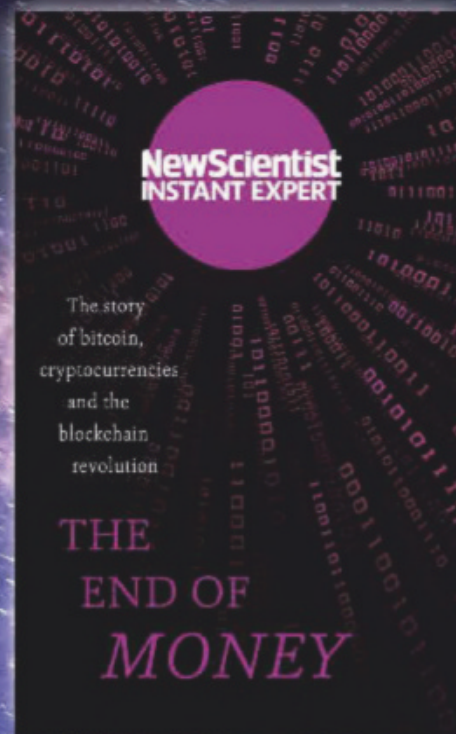
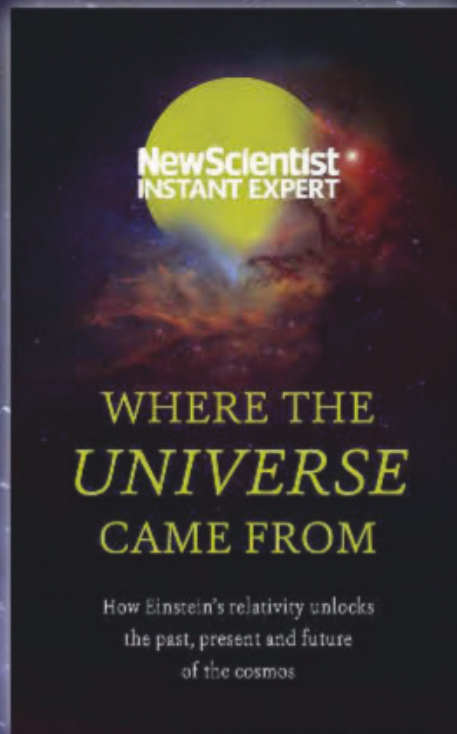
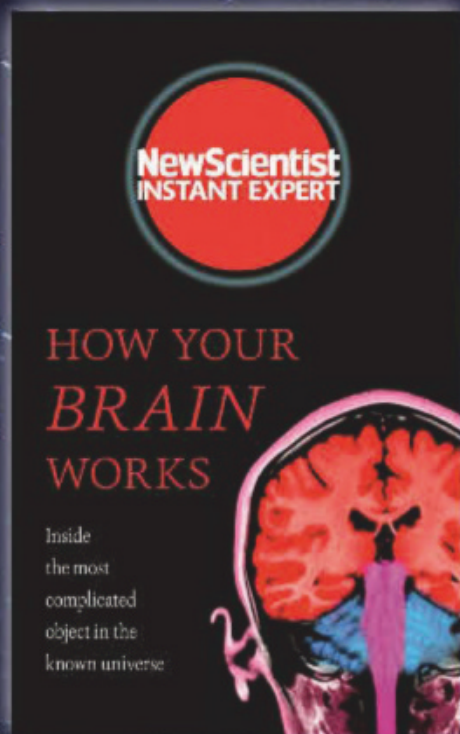


PHOTO ESSAY

LAND OF THE GIANTS

Atop a desert mountain in northern Chile, the world's most powerful optical telescope is a testament to astronomers' restless desire to see further.

Words by Daniel Cossins. Photographs by Enrico Sacchetti

ANTU, Kueyen, Melipal, Yepun. These four hulking figures dominate the summit of Cerro Paranal, a rust-red mountain in Chile's Atacama Desert. Their home is among the most inhospitable places on Earth – a desolate, dusty terrain reminiscent of the surface of Mars.

As night falls, the giants slowly rotate and stir into life. Doors slide open, and within the structures vast mirrors begin to capture light from distant corners of the universe.

Together they make up the world's most powerful optical telescope: the Very Large Telescope.

You might have seen some of the VLT's spectacular snapshots of swirling nebulae and far-away galaxies. But it was not built just to take pretty pictures. In the 20 years since the VLT saw first light, it has given researchers of the European Southern Observatory, a 17-nation astronomical collaboration, a clearer view of phenomena that

could answer some of the universe's greatest open questions, from how stars and planets form and whether there is life beyond our solar system, to how our underlying theories of the cosmos stand up. But enough is never enough: the giants are evolving, with the promise of even more spectacular discoveries to come.

This corner of Chile is an astronomer's paradise. The sky is cloudless for 330 days of the year, there is almost no light pollution



P H O T O E S S A Y



and the air contains barely any moisture that would otherwise block certain wavelengths of light. “When the moon is down, the night sky is absolutely amazing,” says staff astronomer Jonathan Smoker, who spends four months of the year on the peak. “The Milky Way is as clear as day.” But even in near-perfect conditions, you need a whopping amount of light-gathering power to peer deep into the universe.

Each of the VLT telescopes has an 8.2-metre-wide mirror. Bigger single mirrors do exist, such as the two 10-metre telescopes at the Keck Observatory atop Mauna Kea on Hawaii. But the VLT has a special feature that sets it apart. It can combine light from all four

mirrors and computationally reconstruct them into a single image. Together with the output of smaller, auxiliary telescopes, this effectively creates a single mirror up to 200 metres wide. This unrivalled light-gathering apparatus can distinguish two car headlights at the distance of the moon.

Right from the beginning of its career in 1998, the VLT has been producing images that both confirm and challenge our understanding of the universe. Although the first planets orbiting other stars had been discovered in the 1990s, their presence had only been deduced by their influence on their parent stars. In 2004, the VLT snapped the first direct image of an exoplanet, opening

an era in which we could not only see these alien worlds, but also infer what their atmospheres are made of. A few years later, it took the temperature of the distant universe by analysing carbon monoxide molecules 11 billion light years away. The result was in almost perfect agreement with what our theories predict for a universe that started with a big bang.

But there is always some answer that lies just out of sight, even of the most powerful telescope. So even if it ain’t broke, fix it.

Various factors beyond mirror size limit a telescope’s performance, such as the effects of atmospheric turbulence. The Paranal Observatory, home to the VLT, sits 2650 metres up. Here the air is thinner than at sea

P H O T O E S S A Y



Previous page: The mountaintop of Cerro Paranal in the Atacama desert was blasted away to create a level site for the Very Large Telescope

Above: The four main individual telescopes of the VLT are named after objects in the sky in the Mapuche language of the indigenous people of south-central Chile: Antu (the sun), Kueyen (the moon), Melipal (the southern cross) and Yepun (Venus). Each of the four main observatories contains an 8.2-metre-wide mirror, and the light collected by these can be combined to create an unrivalled light-collecting device

level, but the constant churning of atmospheric gases still randomly bends light, making stars twinkle to our naked eyes and blurring telescope images.

The VLT has always had a sophisticated system of adaptive optics designed to correct for such effects, but it has recently undergone a significant upgrade. In 2016, Yepun gained a deformable secondary mirror just 2 millimetres thick, studded with almost 1200 actuators that constantly reshape the surface in real-time in response to measurements of atmospheric distortion. The same year also saw the addition of GRAVITY, a system that more subtly controls the light from all the individual telescopes

to sharpen the resulting images.

With these upgrades, the VLT has in the past 12 months captured the first image of a planet forming in the dusty disc around a young star, measured the chemical composition of an asteroid in the frigid outer solar system, observed the aftermath of a collision between two neutron stars and analysed the atmospheres of the seven Earth-sized worlds around the TRAPPIST-1 star, several of which appear to be rich in water.

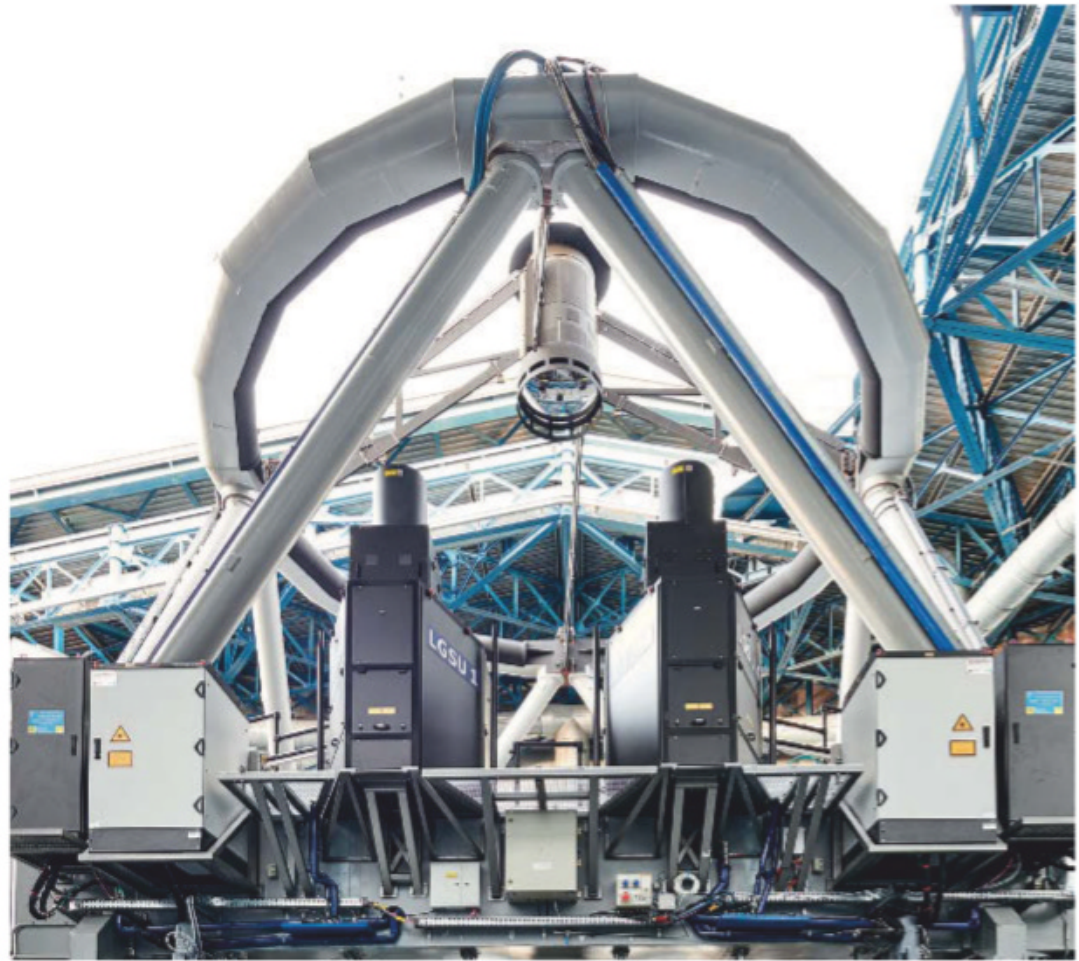
But perhaps its most impressive recent observation is of a star sailing perilously close to Sagittarius A*. This monster black hole, 4 billion times the mass of the sun, sits at the Milky Way's centre some 25,000 light years away. Astronomers have been watching ➤

PHOTO ESSAY



P H O T O E S S A Y

Left: The Four-Laser Guide Star Facility is a feature of the upgraded Yepun telescope. Its intense yellow beams excite sodium atoms in the upper atmosphere, which act as artificial stars for calibrating the VLT's optics. Right: In the telescope's interior, each beam is generated in a "laser launch telescope" (the black objects visible bottom-centre)



this star, known as S2, since the early 1990s. They knew its elliptical orbit would eventually take it close enough to Sagittarius A* to enable the most stringent tests ever of Einstein's general theory of relativity, which describes gravity's effects.

S2 is very faint, making it tricky to observe with the necessary precision. "Both the star and the black hole are very far away, and there is a thick veil of dust between us and the galactic centre that allows precious little light to penetrate," says Oliver Pfuhl at the Max Planck Institute for Extraterrestrial Physics in Germany. But in May 2018, as S2 made its closest pass of Sagittarius A*, Pfuhl and his colleagues used the VLT to clock its speed at 7600 kilometres per second and measure its wobble towards and away from Earth. The black hole's immense gravitational field stretched the star's light by almost precisely the amount that general relativity predicts.

The VLT has continued to track S2 in the hope that it can give us a clearer picture of what the fabric of the universe does around a supermassive black hole. "You can basically trace space-time in a place that nobody has

traced it before," says Pfuhl.

The next step is to trace it in a galaxy that's not our own. That could become possible thanks to a gizmo fitted to Yepun in 2016. It shoots four powerful lasers into the upper atmosphere. "See the photos and you might think they were taken with a long exposure or Photoshopped, but it's not true," says Smoker. "You see the lasers with the naked eye."

Now fully operational, the beams of the Four-Laser Guide Star Facility excite sodium atoms in the atmosphere to act as artificial guide stars to calibrate the instrument. The light they give out is analysed 1000 times per second to see how turbulence is distorting the atmosphere, and so what contortions the adaptive optics must perform to counter it. This should allow the VLT to achieve images with a sharpness close to the theoretical limit for a telescope its size, says Joël Vernet, a VLT researcher. It may even let us track stars around supermassive black holes that lurk in galaxies beyond our own.

And when that is no longer good enough? Just 23 kilometres from the Paranal Observatory, on another of northern Chile's dusty mountaintops,

construction recently began on an even larger telescope. The Extremely Large Telescope (ELT), slated to start imaging the universe in 2024, will build on the technology of its predecessor, but boast a main mirror almost 40 metres wide. "That is a huge boost in light-collecting power," says Vernet. With a virtual mirror like the VLT's, you can only see bright objects at the farthest distances.

The ELT should give us a view of the very first, faint galaxies, imparting new clues about how structure in the universe evolved. It could provide the first direct measurement of the accelerating expansion of the universe, shedding light on the mysterious dark energy that appears to be causing it. The telescope will even search for variations in the fundamental physical constants over time, and so challenge the very basis of the laws of nature.

The restless imaginations of astronomers and cosmologists are already stirred. "We can't wait to see it," says Smoker. ■

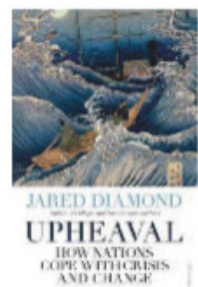
Daniel Cossins is a staff writer for *New Scientist*. Enrico Sacchetti is a photographer based in Rome, Italy

Books of 2019: Get even smarter this year

From Einstein to survival, here's a sneak peek at the best forthcoming books

Upheaval: How nations cope with crisis and change

by Jared Diamond, Allen Lane



A NEW book by Jared Diamond should be something of an occasion, and *Upheaval* is unlikely to disappoint,

especially in our turbulent times. Diamond won a huge global following with *Guns, Germs and Steel* (1997) and *Collapse* (2005), when he drew on ecology, evolutionary biology, anthropology and geography to help us rethink the way we understand civilisations. Now his latest, *Upheaval*, is being touted as the final book in this trilogy.

This time, his mission is to reveal how nations can successfully recover from crisis by taking a close look at how seven countries survived major upheavals in their recent past. His case studies range from the Soviet invasion of Finland in 1939 to Augusto Pinochet's dictatorship in Chile from the 1970s to 1990.

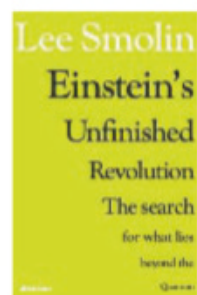
But the big lessons for now come when he asks if we are squandering our resources and advantages to the point of inevitable catastrophe. Can we, will we, learn from the past? Should nations and individuals withstand disaster by becoming more resilient? Brace yourselves.

A nice counterpoint to the monumental Diamond is *There*

is No Planet B: A handbook for the make or break years by Mike Berners-Lee (Cambridge University Press). This is a wonderfully comprehensive round-up of everything you need to know to (possibly) survive, from climate change to veganism to flying in a low-carbon world to the end of antibiotics – and which of our myriad problems is most pressing. **Liz Else**

Einstein's Unfinished Revolution: The search for what lies beyond the quantum

by Lee Smolin, Allen Lane



IN AN obvious if rather lovely irony, quantum physics has always led a double life. It fundamentally shifted our world

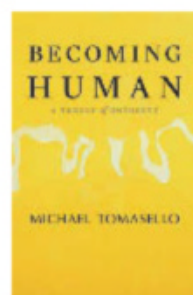
view by building a new picture of life at the subatomic level, explaining everything from elementary particles to the behaviour of materials. But it also created bitter divisions over which interpretation best describes our world.

For a few years now, theoretical physicist Lee Smolin, a pioneer of the theory of loop quantum gravity (one of the big hopes for developing a quantum theory of gravity), has thought he has an answer. The reason quantum physics is still so contentious is that the theory is incomplete, that quantum mechanics doesn't provide an explanation for what happens at a larger scale

because it leaves out aspects of nature needed for a true description. In *Einstein's Unfinished Revolution*, Smolin works through alternative interpretations, from pilot wave theory to the many worlds interpretation – only occasionally, becoming textbooky. He ends up with his own theory – and that, as your parents might have said, you will have to discover for yourselves. **LE**

Becoming Human: A theory of ontogeny

by Michael Tomasello, Belknap Press



WHAT makes us human and when does that happen? Evolutionary anthropologist Michael Tomasello has produced a book that anyone really interested in one of the big questions will take on many a holiday (it is a demanding read).

Tomasello identifies eight developmental pathways that differentiate us from our closest relatives: social cognition, communication, cultural learning, cooperative thinking, collaboration, prosociality, social norms and moral identity. These exist in great apes at rudimentary levels, but our capacity to develop shared intentionality over the first few years of life transforms these abilities into uniquely human cognition and sociality.

And in *The Goodness Paradox*:

How evolution made us both more and less violent (Profile Books), Richard Wrangham, a biological anthropologist, picks up on one behaviour that may be near-exclusive to humans: despite being less violent than most undomesticated animals, we may be the only ones that go to war. **LE**

Underland

by Robert Macfarlane, Hamish Hamilton



THIS summer, Robert Macfarlane takes his unique and influential brand of culturally aware nature writing to subterranean territory. Covering graves, mines, caches and temples, he brings to light a history of eerie, sometimes epic human journeys into the

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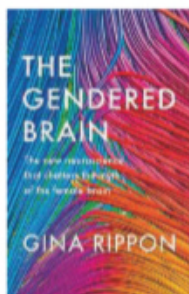


earth beneath our feet.

We have always, he says, plumbed Earth's depths with the same three ideas in mind: "to shelter what is precious, to yield what is valuable, and to dispose of what is harmful". It is a timely project as the melting of Arctic ice is causing ancient methane deposits to leak into our carbon-burdened atmosphere, along with anthrax spores from freshly defrosted reindeer corpses.

But Macfarlane isn't warning of some future apocalypse so much as writing about the world we are living in now: a reality we are just too confused, distracted or afraid to face; a world in which all the "things that should have stayed buried are rising up unbidden". *Underland* is a profoundly beautiful, and profoundly disturbing, book. **Simon Ings**

The Gendered Brain: The new neuroscience that shatters the myth of the female brain
by Gina Rippon, Bodley Head



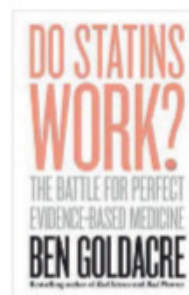
WILL 2019 see an end to the "neurotrash" we talk about women's and men's brains? In *The Gendered Brain*, Gina

Rippon clearly hopes so as she sets out to tear down the idea of describing a brain as "male" or "female", and mapping onto those descriptions everything from behavioural differences to life choices.

It is, she writes, a notion that has driven brain science into a bad place, and hemmed us in with "damaging stereotypes". The neurotrash must go, she says,

along with binary views about ourselves. Embrace instead the most up-to-date science showing that brains are highly individual, adaptable, complex organs with amazing potential. **#LetsHope. LE**

Do Statins Work? The battle for perfect evidence-based medicine
by Ben Goldacre, Fourth Estate



IN 2014, rationalist campaigner and Bad Science blogger Ben Goldacre wrote that he was thinking of "rattling out a very quick 90-page book on statins". Some five years later, his *Do Statins Work?* is more than 300 pages long, and no wonder. These cholesterol-reducing medications are the single most prescribed drug in the developed world, but big pharma's inability to measure and discuss side effects properly means the rest of us can't make informed decisions about their use.

This can be fixed, argues Goldacre, by wedding big data to the art of medicine. Has he hit on a solution, or is he courting even bigger controversy? **SI**

Luna: Moon Rising
by Ian McDonald, Tor Books;
Zero Bomb
by M.T. Hill, Titan Books



THE Luna trilogy by Ian McDonald has been optioned for TV by CBS. But there is no need for any of us to wait for the televised version: *Luna*, the final volume, is published this spring, and promises an even bigger than usual helping of dynastic infighting, espionage and murder. Of the five clans who control its biggest industries, who will, at last, rule the moon?

Meanwhile, back on Earth, a grief-stricken, middle-aged bicycle courier finds himself without insurance, terrorised by a fox, and caught between worlds in M.T. Hill's *Zero Bomb*. This is arguably the finest post-singularity escapade since Matthew de Abaitua's sci-fi novel, *If Then*. And if you haven't read that, then look forward to a delightful time catching up. **SI**

The Demon in the Machine: How hidden webs of information are solving the mystery of life
by Paul Davies, Allen Lane



EXPLAINING one of the oldest questions – what is life? – is physicist Paul Davies's quest in his latest book, *The Demon in the Machine*. He searches for answers beyond the known, venturing into a place with no name where computing, chemistry, quantum physics and nanotechnology intersect, thanks to the idea underlying them all – the concept of information. **LE**

Apollo 11: The inside story
by David Whitehouse, Icon Books



WE MAY not make it to the 50th anniversary of the moon landing, killed off instead by a meteor shower of celebratory books.

On the bright side, one of the best so far is *Apollo 11*, by former BBC science correspondent David Whitehouse, who happens to have an asteroid named after him (asteroid 4036 Whitehouse). This is a terrific and enthralling tale of Neil Armstrong, Buzz Aldrin and Michael Collins (as pilot of the command module, he was clearly the drummer in the band) and glory on the moon. **LE ■**

CULTURE

Roll up to the future

Visions of a better tomorrow dominate **Simon Ings's** events diary

Spare Parts

Science Gallery London
28 February to 12 May

THIS winter, curator Stephanie Delcroix's new exhibition asks peculiar and pressing questions about the body.

It is nearly 65 years since Joseph Murray and a team at the Peter Bent Brigham Hospital in Boston performed the first successful organ transplant (passing a kidney between identical twins Ronald and Richard Herrick), and still our imaginations are haunted by the mystery, menace and sheer potential of maintaining human life with spare parts.

Exoskeletons and prosthetic limbs blur the distinction between human and machine, but it is beneath the skin where things get really weird. Organ transplants from other species are a real possibility, now that we can use CRISPR gene editing to inactivate viruses in piglet DNA that might be harmful to people. Fecal transplants, first developed to treat infections of *Clostridium*

Salomé Bazin's bespoke 3D-printed hearts aid pre-operative planning

difficile, are being hailed as a possible weapon against the obesity pandemic. And maverick neurosurgeon Sergio Canavero garners headlines for his plans to transplant human heads. Researchers are even making artificial hearts out of foam.

Spare Parts will explore how our sense of ourselves is changing in response to these and other advances. Are we empowering ourselves, or losing ourselves? Are we perfecting our existence, or eroding any sense of what is good in life?

Smoke and Mirrors

Wellcome Collection, London
11 April to 15 September

NOW you see it: now you don't – the link between magic and psychology, that is – in the Wellcome Collection's exploration of prestidigitation, illusion, bias, suggestion and plain gullibility. Magic fans will coo over items from classic routines by Derren Brown, Tommy Cooper, Paul Daniels, Debbie McGee and Harry Houdini. And everyone can worry about what all this credulity means for politics.

Is This Tomorrow?

Whitechapel Gallery, London
14 February to 12 May

VISIONS of the future from leading architects and artists address new technologies, the environment, migration and resource scarcity in a homage to the groundbreaking 1956 Whitechapel Gallery exhibition, *This is Tomorrow*. Nearly a thousand people a day visited that exhibition, dubbed by one critic as "a game people will want to play". Will today's public be as receptive to new ideas?

AI: More than human

Barbican Centre, London
16 May to 26 August

BIG questions are posed in this interactive exhibition exploring creative and scientific developments in the world of artificial intelligence. New artistic commissions examine the boundaries between human and machine. There are also films, workshops and a concert series helmed by mathematician Marcus du Sautoy.

Mars

Design Museum, London
16 October to 1 March 2020

HOW will we get to Mars, let alone survive there, let alone thrive? The Design Museum joins in this evergreen debate with an immersive exhibition that promises to give visitors a true sense of the surface of Mars, and the likely shape of human life, should we ever get there. From spaceships to habitats to the politics of a new society, Mars is a speculative designer's dream. ■

DON'T MISS

Last chance

Saturated: The allure and science of color, at the Cooper Hewitt museum, New York, runs until 13 January. More than 190 objects show how theories of colour are used in design to order and brighten our world (pictured).

Listen

Physicist Brian Cox and comedian Robin Ince return for a new series of the science/comedy show *The Infinite Monkey Cage* on 7 January at 4.30pm GMT on BBC Radio 4. First up, they suggest that microbes, not humans, are Earth's true masters.

Read

Quasicrystals are the subject of Paul Steinhardt's book *The Second Kind of Impossible: The extraordinary quest for a new form of matter* (Simon & Schuster). And if it all gets too much, read *Empty Brain - Happy Brain: How thinking is overrated* by Niels Birbaumer and Jörg Zittlau (Scribe).

Visit

Swedish artist Jonas Lund reckons he can use new propaganda techniques to reverse Brexit – or that it might be fun to try. Support (or sabotage) *Operation Earnest Voice* between 10 and 13 January at The Photographers' Gallery, London. It is part installation, part performance, part think-tank.

Play

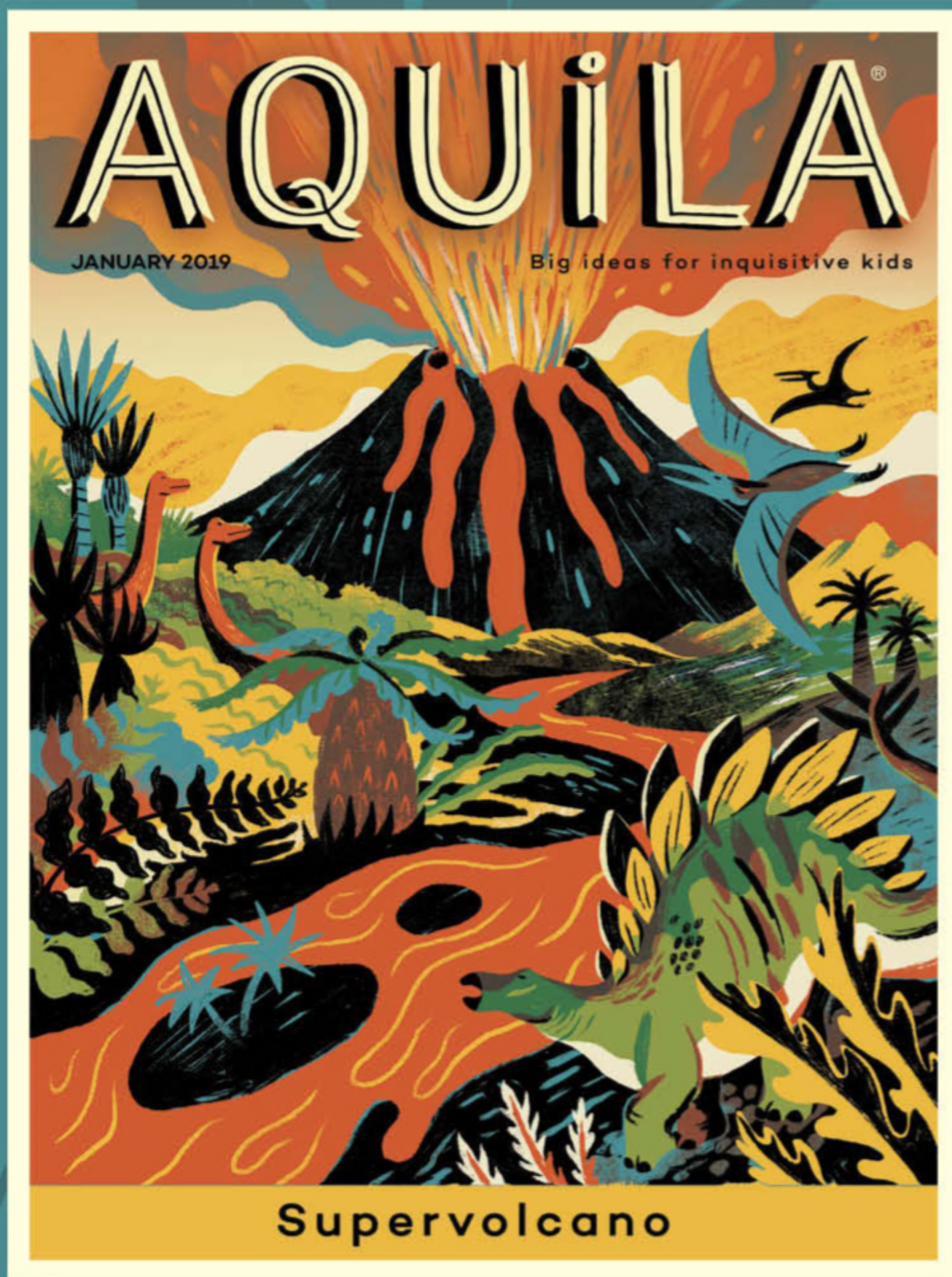
Double Cross by 13AM Games is out on 10 January, plunging players into alternate worlds and secret agendas. Can you save the multiverse?



BIG HEART DATA (2018), SALOMÉ BAZIN (CELLULE-STUDIO), GARETH MCKEE



MATT FLYNN © SMITHSONIAN INSTITUTION



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NOMINATIONS

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- 2) A summary of the significance of this research in the fields of biology or biochemistry (no more than 500 words).
- 3) A brief biographical sketch of the nominee, including positions held and awards received by the nominee.
- 4) A key publication list of up to ten of the nominee's most significant publications relating to the research noted under item 1.
- 5) A copy of the nominee's curriculum vitae.



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Representative publications:

Arthritis Rheumatol. 67:2061-70, 2015
Arthritis Res Ther. 18:161, 2016
Rheumatic and Musculoskeletal Dis. 2 (2), 2016
Proc. Natl. Acad. Sci. (USA) 15:4755, 2018

Qualifications:

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Joseph Holoshitz, MD, Professor of Internal Medicine,
 University of Michigan School of Medicine, 5520 MSRB1
 1150 W. Medical Center Drive, Ann Arbor, MI , 48109-5680

Email: jholo@med.umich.edu



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<https://careers.utrgv.edu/postings/19706>

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EDITOR'S PICK

Have we blown our chance on climate - or not?



From Blaise Bullimore,
Tiers Cross, Pembrokeshire, UK

I agree wholeheartedly with your exhortation not to blow the chance to save our climate (Leader, 8 December 2018). But barring a major miracle, it is game over: not for saving the planet itself, of course - despite the universal shorthand, it will survive in some state

or other - but for saving a planet fit for supporting humanity and a good slice of other life forms.

The necessary timescales for the essential, tough actions you describe in the same edition (p 31) leave no place for optimism. Let's set aside for a moment the likes of Trump and the commitment to exponential growth in the current economic model. You give evidence of the kind of inertia to be overcome, with the aviation sector seeking to avoid limits on emissions (p 15) and BP advertising a relatively minor fall in fuel consumption from carrying fossil fuels to market (p 38) by ship, as if that will cut the mustard.

At 65, I will be spared the worst of the impacts of climate change. The fate of everyone under the age of, say, 40 terrifies me, though. Speaking on behalf of her generation at last

month's UN climate summit in Poland, 15-year-old Greta Thunberg said "we have not come here to beg the world leaders to care for our future. They have ignored us in the past and they will ignore us again. We have come here to let them know that change is coming whether they like it or not."

From Mini Grey, Oxford, UK

I would add lobbying for a meaningful price on carbon as another powerful individual action to deal with climate change. Taxation is never popular. But returning money from a fee on carbon at source to all citizens through a monthly or yearly dividend could be a clearly fair and planet-changing policy.

It starts a virtuous spiral towards low-carbon energy and innovation. Canada is already implementing a carbon fee and dividend policy.

Handy guidance on ritual meanings in cave art

From Ruth Ridley,
Seaford, East Sussex, UK

I was interested by your article on finger sacrifice possibly depicted in cave art (8 December 2018, p 16). Might this art be a form of prayer? Today we sometimes say "I'd give my right arm" for something, but we don't actually remove it. Perhaps this art was a plea to the gods for something of importance to the person that made it.

From Robert Winston,
London, UK

The loss of fingers seen in the stencils on the walls of Gargas cave in France seems to me unlikely to be due to frostbite. Fingers are often missing, but never the thumb, surely ruling this out. It is also less likely to be due to some ritual amputation.



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"In future they'll excavate the bones and deduce a massive chicken-worshipping cult"

Marjorie Meldrum predicts how the Anthropocene being marked by a layer of chicken fossils could play out (22 December 2018, p 18)

Different fingers are missing on different hands, suggesting that the remaining fingers are being held erect. Given that these images are deep in the cave, it seems more likely that the slivers of animal bones inserted into crevices in the cave walls near the stencils are relevant. Surely the slivers represent the source of protein that prehistoric humans prayed for in times of famine? It seems likely that these fingers held up represent a species to be hunted and the hands are painted in supplication in the oldest known "cathedral".

Remembering scientists personally as humans

From Peter Harris, Watford, Hertfordshire, UK
The Bank of England asked the public to nominate dead scientists to portray on the £50 note

(10 November 2018, p 24). Is there something all too impersonal in the way we in Britain celebrate achievement in science?

I nominated Benjamin Thompson (1753-1814), who was born in British North America and had the idea to found the Royal Institution. The Royal Society awards a medal in his honour. For the past century and a half, biographies have all commented on how he is all but forgotten.

No one, these bodies included, seemed to notice the bicentenary of his death, which took place in August 2014. I went to his grave in Paris and sat there all day, curious to see who else would turn up. Nobody did.

On 27 October 2018, the 50th anniversary of the death of physicist Lise Meitner, I went to her grave, 9 kilometres from the Atomic Weapons Establishment at Aldermaston in Berkshire, UK.

The place was, of course, brought into being by her discovery of nuclear fission. No one else visited from dawn to dusk.

Compare this with the coach party and a dozen more people who turned up in April 2017 at the grave of the poet Edward Thomas near Arras, France, on the centenary of his death, or the 2017 service by the grave of novelist Jane Austen in Winchester, UK, for the bicentenary of her death.

The 500th anniversary of the death of polymath Leonardo da Vinci is on 2 May 2019. He is buried in Amboise, France.

Our working weeks have gradually got shorter

From Shelley Charik, London, UK
Richard Mellish claims that the working week hasn't grown shorter as predicted by the

economist John Maynard Keynes (Letters, 24 November 2018).

According to figures collected by Michael Huberman and Chris Minns for a 2007 article in *Explorations in Economic History*, full-time production workers around the world worked for 64 hours a week on average in 1870, but this steadily fell to around 40 in 2000. It seems to me this shows that Keynes was right.

The figures for males in 2000 range from 36.9 hours in France and Spain to 43.3 in the US. Huberman and Minns attribute this range to differences in labour power and equality.

More on the downsides of destroying drugs

From Andrew Vickers, Quernmore, Lancashire, UK
Ed Hillsman is concerned that "vaccination" against opioids

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would render these drugs useless if a person later has medical need for them to relieve pain (Letters, 17 November 2018). We already face this problem with naltrexone, an opioid antagonist used to prevent relapse in addiction. People receiving naltrexone will be very resistant to opioid analgesia. This can pose major therapeutic challenges when they are in acute pain (BMJ, doi.org/fbs9p2). All those receiving naltrexone, particularly if their work or recreation involves risk of injury, should be informed of the potential problems.

Australia may have even older figurative art

From Stuart Leslie, Dorrigo, New South Wales, Australia

In the article on the cave painting found in Borneo (17 November 2018, p 18), it is claimed it may be the oldest figurative art in the world at 40,000 years old. In Australia, there are two detailed rock paintings depicting the marsupial carnivore *Thylacoleo carnifex* and two of the giant flightless bird *Genyornis newtoni*.

Although the paintings can't be dated, fossils of these creatures are widespread and it seems none is younger than 46,000 years old. Unless younger fossils are found, I suggest these are contenders for the oldest figurative art produced by *Homo sapiens*.

We find that much food waste hard to believe

From Victor Cheetham, Blackrod, Lancashire, UK
Chelsea Whyte asserts that 30 per cent of food is thrown away (8 December 2018, p 22). I asked around my friends and we all eat almost all that we buy. Aside from peelings, little is wasted. So who are these people wasting so much food? Do we need to reintroduce domestic science at school?

From Mark Wilson, Elmgate, Cornwall, UK
You say the average person in the US discards almost 3 kilograms of food waste per week. I weighed our food waste bin for a week and I can exclusively reveal that our household "wastes" 1.5 kilograms of food per person per week. This

consisted, however, of vegetable and fruit peelings, banana skins, two rotten apples, many tea bags and coffee grounds.

None of this is really food, but all is compostable and I suspect it would be added to our local council's food waste statistics.

The editor writes:

■ The number is based on a US Department of Agriculture study from 2007-2014 that modelled food loss at multiple stages in the system for over 200 foods. It takes into account food spoiling in the pantry or fridge, and food wasted in cooking or left on the plate. It excludes non-edible parts. It does include half-eaten hamburgers tossed out from fast-food joints.

How does that zero-emission plane lift off?

From Derek Malpass, Hohenthann, Germany

I was interested to read about the zero-emissions model aircraft (24 November 2018, p 7). You say that the electrodes produce ions that push against the surrounding air. I am old enough to remember

the advent of jet aircraft in the 1940s. How could they possibly fly with no visible propeller? "They push on the air behind them" was a frequently heard response from people who didn't understand Newton's third law of motion: for every action, there is an equal and opposite reaction, as when the action of the jet exhaust causes the reaction of the plane's motion.

The editor writes:

■ Many readers asked about this. The electroaerodynamic (EAD) propulsion that the plane uses is different from jet propulsion or ion thrusters for spacecraft. EAD doesn't push ions out: it creates ions in the surrounding air, which collide with neutral air molecules.

Bring on the social traitor robot rat poison decoys

From Peter Tier, Dunedin, New Zealand

Research has found that rats will help free a robot rat from a cage, possibly in the hope that it will return the favour in future (1 December 2018, p 8). Bring on a robot rat that will lead the pack to the poison dish and then "eat" a portion with no ill effect.

For the record

■ Physicist Miguel Escudero is now at King's College London (1 December 2018, p 36).

■ Bitcoin mining is estimated to use 45.5 terawatt-hours of energy per year (15 December 2018, p 5).

■ When two particles are in quantum entanglement, measuring the state of one determines the measured state of the other (15 December 2018, p 10).

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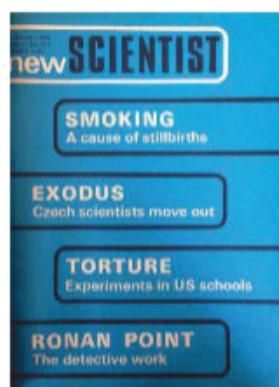
TOM GAULD for NEW SCIENTIST

FROM THE ARCHIVES

Fifty years ago, the Soviet invasion of Czechoslovakia was having a chilling effect on scientists working there



SOVPHOTO/UC VIA GETTY IMAGES



"THE scientists are getting out." Our headline on 9 January 1969 referred to a significant moment in cold-war history. Teachers, doctors, researchers and students were leaving Czechoslovakia in their thousands, and had been doing so since 21 August of the previous year.

That was when the tanks had rolled in. Around 250,000 troops from the USSR, Poland, Hungary

and Bulgaria invaded the country, bringing an abrupt and decisive end to the Prague Spring, a period of liberalisation and democratisation that had begun earlier that year.

"When, in January 1968, the Stalinist party-leadership was replaced by new men who appreciated the importance of science, most scientists were convinced that the time of change had actually arrived," we wrote. "The Soviet invasion... came as a great shock."

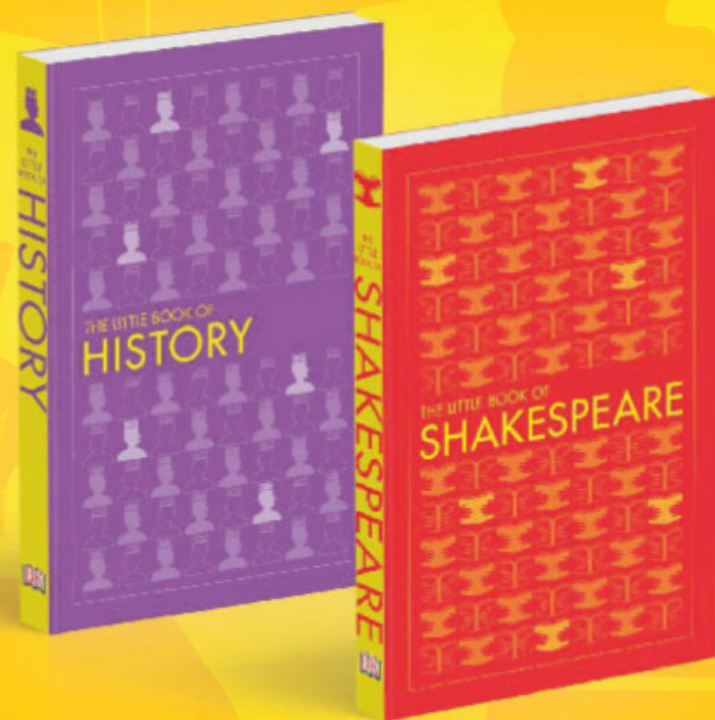
By January 1969, several centres of research "were practically brought to a standstill by the depletion of their staffs". Many scientists had been actively involved in attempting to reform the regime, but "only a few left the country because of personal danger", we wrote. "The real reason for this massive exodus is the justified fear that the bad old days will return."

Those days had not been favourable for scientists. "Leading posts in government and industry were taken over by people who not only lacked education but were hostile to it," we wrote. "Subsequent purges made it quite clear that a university degree was not only a great disadvantage but often a source of danger." Even if someone managed to become a researcher, "the classification of scientific theories and results as either 'Marxist' or 'bourgeois' made it impossible for scientists in East Europe to take part in the important advances achieved in the field of genetics, cybernetics, information theory and psychology".

That situation was set to continue for 20 years. It was not until the Velvet Revolution of 1989 that Czech scientists could truly restart their work. By then, we wrote in 1990, the country had lost a generation of scientists. **Julia Brown** ■

To delve more into the *New Scientist* archives, go to newscientist.com/article-type/old-scientist/

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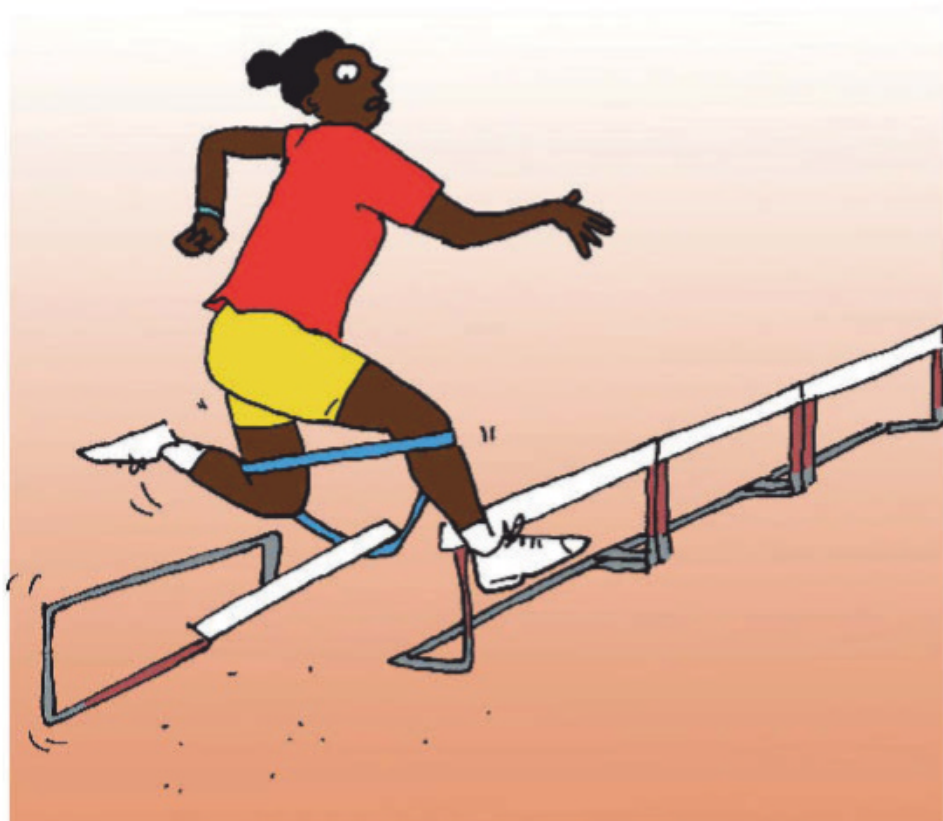
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FEEDBACK

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NEW year is a time of optimism, hasty resolutions and no-refund introductory gym memberships. Just the time, then, to try out the latest fitness craze inspired by science. Wrap up your brightly coloured muscle tape, the must-have device this year might be a rubber band.

Reasoning that tendons store energy, making running more efficient, Cole Simpson at Stanford University in California and his colleagues tried adding an extra one to humans. Their "exotendon", cunningly disguised as a rubber band, joins a runner's legs as if some gym bully has tied the laces of your favourite running trainers together. The elastic material is short enough not to tangle the feet, but long enough to encompass a full stride.

Simpson's team found that the exotendon certainly did put a spring in the step: joggers sporting the elastic link saw an average of a 6.4 per cent increase in running economy.

Impressive, but Feedback is keen

to expand the findings. We're going to dust off our old inline skates and improve our locomotion efficiency even further by attaching one end of the elastic to our front door. That way, we can skate to the nearest sale of leftover festive chocolate, and let the spring pull us home again.

A STARTLINGLY human-like robot was caught on Russian TV, performing at a state-sponsored technology event last month. Viewers were amazed as the android, reportedly the most advanced in the world, walked, talked and danced. Unfortunately, cynical viewers soon pointed out that the robot looked uncannily similar to a £3000 costume available online.

Yes, the most advanced robot in the world had a human heart – and human arms, legs and everything else. Well, it certainly saves on batteries.

Humans masquerading as

robots is a burgeoning market. In the UK, Titan the Robot (or to give a fuller name, Titan the Impressively Expensive Robot Costume) has played a heady tour of the nation's shopping centres and bar mitzvahs, performing feats that would be considered impressive for a robot, if a robot did them.

Sadly, Feedback suspects that it is only a matter of time before creeping automation replaces these human performers with robots pretending to be humans pretending to be robots pretending to be humans.

NEW year can be a quiet time in the office, but nowhere more so than in Mozambique. The nation's government says it has identified 30,000 "ghost workers" in the civil service, costing about £100 million a year. Some ghost workers were genuine employees, but were being paid to do non-existent jobs.

Others were dead or fictitious – yet corporeal enough to draw a salary every month. Ministers used a proof-of-life test to root out fake staff (no details, but we do hope it involved *Blade Runner*-style questions about turtles in the desert). A spokesperson told journalists that from now on, only one employee would be hired for every three that left the civil service.

But is this the future? The phenomenon of, er, inconsequential jobs is well known in the West, which has dogmatically stuck to the idea of full employment and a 40-hour work week, despite plateauing productivity. As anyone knows, doing a job in half the time simply means looking busy for the other half. Instead of purging these enterprising non-workers, Mozambique should simply rebrand it as the world's greatest universal basic income experiment.

HATERS gonna hate, but that doesn't mean you shouldn't take proactive measures against them. *Rolling Stone* reports that face recognition was deployed at a Taylor Swift concert, in an effort to protect her from stalkers.

Keeping performers safe is an

understandable goal, but Feedback worries about the spread of such technology. The privacy implications of being recorded at a Taylor Swift concert are one thing, but what if, uh, someone should be spotted attending a Chesney Hawkes tribute act? Asking for a friend.

TONY BENNETT left his heart in San Francisco, but that's because he wasn't flying Southwest. One of that airline's domestic flights from Seattle to Dallas was recently sent back when a human heart was discovered on board.

The cargo, intended for a Seattle hospital, had been loaded at the previous stop in Sacramento, California. "Nothing is more important to us than the safety of our customers and the safe delivery of the precious cargo we transport every day," a statement from Southwest Airlines read.



STEVE BANNON, former strategist of US president Donald Trump, has found many of his speaking engagements cancelled in the face of public opposition. But the latest may sting more than most.

Organisers of a US conference on sex robots (lambasted by many people as dehumanising) decided that a congress with Bannon was a step too far. So what Bannon knows about sex robots will, for now and hopefully forever, remain a mystery.

You can send stories to Feedback by email at feedback@newscientist.com. Please include your home address. This week's and past Feedbacks can be seen on our website.

"You write that HelloFresh 'doesn't send whole foods to customers that are considered ugly,'" says reader Elizabeth Belben. "I'd have thought ugly people have as much right as anyone else to purchase wonky carrots."

THE LAST WORD

Last words past and present at newscientist.com/lastword

Food for thought

Ignoring the idiom that variety is the spice of life, what single dish could I make that would provide all my nutritional needs forever more? A vegetarian option would be good too.

■ The only dishes that will do this are soups, stews and casseroles. What the reader might consider is the creation of a perpetual stew. Once this mixture starts to boil, it is reduced to a simmer and never turned off. Each day you would add more vegetables and protein, striving for variety. This was a common cooking method in the Middle Ages and there are contemporary examples that have lasted for more than 60 years. To be safe, it is important to never cool and reheat the stew, but to constantly keep it hot.

As for whether a vegetarian or vegan option exists: humans require vitamin B12 and the only readily available sources are from animals, in meat, fish, eggs and dairy products. It would be possible to fortify the stew with B12 additives, but these are often derived from animal sources too.

Stephen Johnson
Eugene, Oregon, US

Some vitamin B12 supplements are synthesised from bacteria – Ed

■ All over the world, people eat a variant of a vegetarian meal containing a legume, a grain and a fruit or green leaf to provide vitamin C. Baked beans on toast with a grilled tomato is a complete

meal, as is hummus with pitta bread and olives. Those on the go can have a peanut butter sandwich with an apple to follow. In Italy, there is pea risotto with lettuce. Native American people cook succotash: a dish of beans, maize and squash.

And in India, lentils, rice and fenugreek leaves have together sustained people for centuries. This would be my suggestion for a universal food.

Alisoun Gardner-Medwin
Heddon on the Wall,
Northumberland, UK

"Usain Bolt typically covers 100 metres in 41 steps, spending 39 per cent of the race on the ground"

■ The doner kebab – a flatbread containing meat, salad and mayonnaise – provides all major nutrients. For a vegetarian option, use a meat substitute such as tempeh (soya digested by a fungus such as *Aspergillus*). It may still need to be fortified with vitamin B12.

Luce Gilmore
Cambridge, UK

■ With a reasonable budget and a lab, you could formulate an optimally balanced meal. You could extract protein from animal or fungal sources to obtain the correct balance of amino acids, and mix this into a carbohydrate flour. Fat can be easily extracted from plant, animal or dairy sources and added to the mixture, as can fibre from plants. A small

amount of sugar and salt may be a welcome addition.

Vitamins and minerals are another easy addition, since they are already synthesised to fortify foods and make nutritional supplements. Finally, you would be well advised to add some flavour extracts or spices to what otherwise sounds a rather unappealing concoction.

Lewis O'Shaughnessy
London, UK

Flying down the track

World-class athletes of both sexes cover 100 metres in about 10 seconds. What percentage of this is spent not touching the ground? And what's the figure for a 2-hour marathon?

■ Every step can be broken into two parts: ground contact time and flight time. As people run faster, the time they spend in contact with the ground decreases, but so too does the time between steps. This means the relationship between the two parts doesn't necessarily change.

The current world record for 100 metres is Usain Bolt's 9.58 seconds, meaning an average speed of 10.4 metres per second. Research has estimated his ground contact time to be 91 milliseconds and his step time to be 236 milliseconds. He typically covers 100 metres in 41 steps, spending 39 per cent of the race touching the ground.

In September 2018, Eliud Kipchoge set a new marathon

record of 2 hours, 1 minute and 39 seconds. His average speed was 5.8 metres per second, and ground contact time at this speed is 110 to 130 milliseconds. Assuming a figure of 120 milliseconds and Kipchoge taking around 25,000 steps, his feet spent about 41 per cent of the race on the ground.

The higher percentage is partly due to differences in how runners land: sprinters do so on the balls of their feet, rarely allowing their heels to touch the ground. In contrast, the heels of even highly trained runners tend to drop during marathons due to fatigue.

It is worth noting, however, the relatively small difference in ground contact times (39 to 41 per cent), highlighting the very high level of training of these athletes.

Laura-Anne Furlong
Lecturer in biomechanics
University of Loughborough, UK

This week's question

HOT TOPIC

I work in catering and often get burned on the hand. Most of these are relatively minor, but painful.

The National Health Service advice is to hold the burn under a running tap of cool water for 20 minutes and not to cover it in anything greasy. As burning is caused by a transfer of energy from one substance to another, even a hot oil burn doesn't need that long to cool down. What is the basis for these measures?

Nick Taylor
Pool, Cornwall, UK

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